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BOSTON SOCIETY OF CIVIL ENGINEERS

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PAPERS AND DISCUSSIONS

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THE METROPOLITAN SEWERAGE WORKS

BY RALPH W. LOUD,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS

(Presented before the Sanitary Section, December 7, 1921.)

BOSTON, the capital city of the Commonwealth of Massachusetts, has now a land area of 43.55 square miles. The Mystic, Charles and Neponset rivers, all of considerable magnitude, intersect or limit this area and discharge into Boston harbor.

The original land surface forming the city proper was of very limited extent. The large increase is due, in part, to extensive reclamations from the adjacent marshes and tidal flats, but chiefly to successive assimilations of neighboring territory. Its present population of 748,060 by the census of 1920, places it in the 7th rank in this respect among the great cities of the United States.

The city is bounded on its landward borders by a metropolitan district lying within a radius of 15 miles from the State House, comprising 25 municipalities, with an area of about 182.7 square miles. The population of these 25 municipalities was estimated at 747,670 as of December 31, 1920.

During the last quarter of the 19th Century with the increasing density of population on the central portion of the areas above defined, the necessity for some satisfactory method of sewage disposal became yearly more urgent. This was especially the case in the city of Boston, where, as early as 1870, an aggregation of old sewers discharged by about seventy outlets into tide water, chiefly along the harbor front. The fluctuations of the tide, particularly in the inner harbor, served to aggravate conditions which were, even without this factor, manifestly inimical to public health and comfort. The numerous complaints received by the city authorities led to the appointment in 1875 of a joint engineering and medical commission, to formulate a remedy for conditions fast becoming dangerous to the public health.

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* Assistant Engineer, Metropolitan District Commission, Sewerage Division, Boston, Mass.

The report of this commission was very broad in its scope, and included proposals dealing with metropolitan districts north and south of the Charles River.

Two systems of main drainage were recommended, one to intercept the sewage of Boston proper, South Boston,* Roxbury,* Dorchester,* Brookline, Brighton,* Newton and other territory between the Charles and Neponset rivers, and to carry it through a pumping station to an outlet at Moon Island.

The second system was intended to deal in like manner with the sewage of Cambridge, Somerville, Charlestown,* Everett, Chelsea, East Boston,* Winthrop and other districts north of the Charles River, by a pumping station at Breed's Island and an outlet at Shirley Gut.

Boston Main Drainage Works

At an early date action was taken on this report by the city, which constructed, from 1877 to 1884, a comprehensive system of sewage disposal works, providing for the area south of the Charles River. The works correspond in their main features with the project proposed and recommended by the commission of 1875, and are known as the Boston Main Drainage Works. They comprise many miles of main and intercepting sewers, ranging from 2½ feet to 10½ feet in diameter, located generally along the tidal margins of the city and lying mainly below the level of low tide; a pumping station at Old Harbor Point, where the sewage is lifted about 35 feet through force mains into twin deposit sewers, in which heavy matters settle before the sewage reaches a tunnel crossing under Dorchester Bay; an outfall sewer built on an embankment leading from the tunnel to the Moon Island reservoir, where the sewage is stored during the latter half of the ebb tide and the whole of the flood tide; and discharge channels leading to the tidal currents in the harbor through which the sewage discharges for one and one-half to two hours during the first half of each ebb tide. Being lighter than the salt water, it rises to the surface, and at the end of half an hour after the discharge covers an area of half a mile in diameter. This can be plainly seen by its color, and also because it contains sufficient grease to still the waves. At the end of another hour it is so far diluted that it is no longer visible, and chemical analysis of the water which has received the sewage shows that by the time it has travelled two miles below the outlet it is but little more polluted than the water which has not come into contact with the sewage, and even less than the water in the harbor near the city.

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* Parts of Boston.

The territory which it was expected would eventually be tributary to these works is bounded by Charles River, Boston Harbor, Neponset River and Mother Brook. It comprises about 58 square miles. The lower portion of this territory, not more than 40 feet above mean low water, and comprising about 12 square miles, was expected to be always tributary to the low-level intercepting sewers, and thus the sewage from this area would always need to be pumped. The sewage from the higher portions of this territory, more than 40 feet above mean low water, and comprising about 46 square miles, was expected to be intercepted by a high-level sewer, to be built in the future, which would convey this sewage by gravity to the outfall sewer beyond the pumping station, thus avoiding the necessity for pumping the sewage from these districts. A branch was left in the outfall sewer, to which a high-level sewer might be connected. As it might be some years before a high-level sewer would be built, and as some portions of the higher districts might require sewerage in the mean time, it was thought best to give to the low-level system a capacity sufficient to provide for the sewage from 3 square miles of the higher districts, in addition to the 12 square miles of low districts properly belonging to that system. The capacity of the main sewer at the pumping station was therefore made sufficient to receive the sewage from 15 square miles of territory.

Volume provided for. — The population to be ultimately provided for upon this territory was estimated at 600,000, being an average of 40,000 to each square mile, a density nearly equal to that of the old city proper. The provision for sewage capacity was based upon an average water consumption of 75 gallons per day for each inhabitant, doubled for the maximum rate, or 150 gallons per twenty-four hours per capita. A provision was made for one-quarter of an inch of rain falling upon the area of 15 square miles in twenty-four hours. It was estimated that this really provided for half-an-inch in that time, as not more than half of a light rain would reach the sewers. For convenience in calculations, the rainfall was taken as one one-hundredth of an inch per hour. In all these computations the proposed sewers were assumed as flowing half-full. These works have been in continuous operation since 1884.

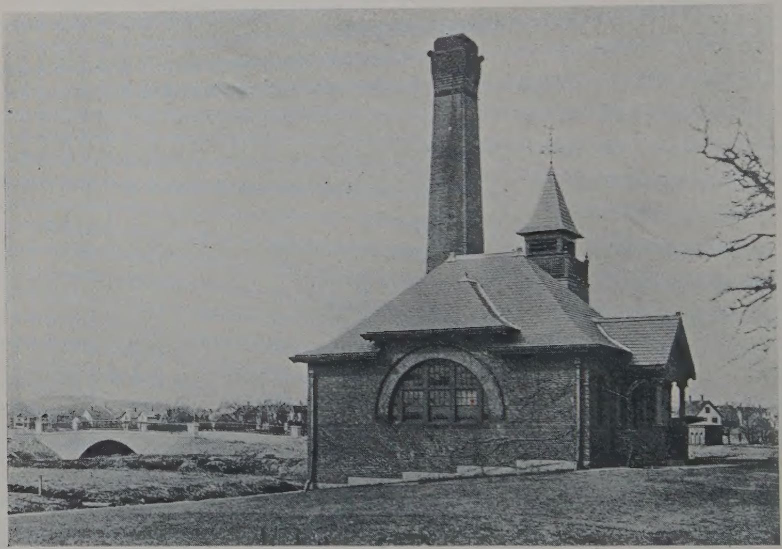

FIG. 1. — ALEWIFE BROOK PUMPING STATION.

During the building of the works described above, increasing attention was directed by the public to the necessity of similar works for the metropolitan district adjoining the city on both sides of the Charles River. The problem was complicated by the difficulty, in many cases amounting to impossibility, of dealing with the sewage of any given area within the borders of the municipality affected. Any sewers constructed for the relief of one such area would necessarily traverse one or more districts under other jurisdiction; and it was finally recognized that no authority, other than that of the Commonwealth, was sufficiently comprehensive to embrace the entire district to be served.

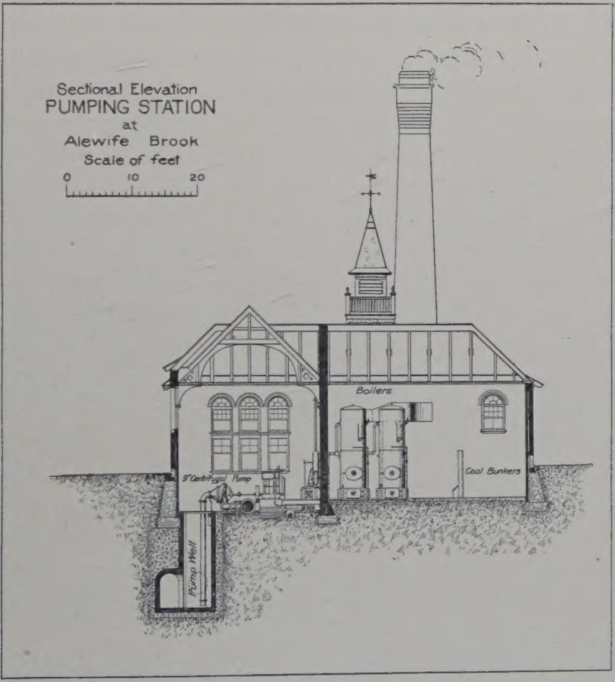

FIG 2.

Successive commissions were appointed to investigate the problem, and to report methods for the relief of the communities affected. The Metropolitan Drainage Commission of 1881 was succeeded by the Massachusetts Drainage Commission of 1884 and 1885. Concurrently with the researches of these bodies the State Board of Health had devoted much study to the general question of sewage disposal; and the Legislature, by chapter 95 of the Acts of 1887, directed that Board to consider and report on a general system of drainage and sewerage for the relief of the Mystic and Charles River valleys, comprising a metropolitan area of about 114 square miles.

The report of the State Board of Health in 1889 recommended the division of the proposed metropolitan district into two parts, dictated by physical and geographical considerations, with an independent harbor outfall for the larger portion, north of the Charles River, designated as the north metropolitan system. In this were then included the isolated Charlestown and East Boston areas of the city of Boston, the cities of Cambridge, Somerville, Malden, Chelsea, Medford,* Melrose,* Everett* and Woburn, and the towns of Stoneham, Winchester, Arlington, Belmont and Winthrop, in all 71.88 square miles. Near Deer Island Beacon,† at the mouth of Boston harbor, was selected as the most suitable point of discharge. The remaining area, about 40.32 square miles, known as the Charles River valley district, included Brighton and part of the Back Bay section of Boston, the cities of Waltham and Newton and the towns of Brookline and Watertown. The Board concluded that this district could be effectively provided for by the construction, south of the Charles River, of an intercepting sewer, following the general direction of the river and to be connected with the Boston Main Drainage System.

The arrangement proposed for the Charles River valley system obviated the necessity for lifting the sewage of that district except at the pumping station of the Boston Main Drainage Works. In the north metropolitan district, however, with its new and separate sea outfall on the opposite side of the harbor, it was necessary to provide independent pumping plant. A study of the conditions, with special reference to the desirability of avoiding excessively deep excavation, chiefly in unfavorable ground and considerably below the level of low tide, resulted in the recommendation to pump the sewage at four different points. Upon this principle a succession of low lifts was adopted, with intervening main sewers at moderate depths, as opposed to carrying the sewage to a lower elevation at a single pumping station with a correspondingly heavier lift. Thus it happens, as will be gathered from a description of the works, that the bulk of the north metropolitan sewage is lifted twice and some of it three times before finally reaching the outlet off Deer Island.

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* Medford, Melrose and Everett were then under town government.

† Deer Island Lighthouse was not in existence at that time.

Metropolitan Sewerage System

The project outlined above received the approval of the Legislature, which, by chapter 439 of the Acts of 1889, constituted a Board of Metropolitan Sewerage Commissioners, consisting of three members, to "*construct, maintain and operate*" the necessary main sewers and other works, substantially as recommended by the State Board of Health in their report of 1889. The original commission consisted of Hosea Kingman (chairman), Tilly Haynes and R. T. Davis. Mr. Howard A. Carson, who had been prominently identified with the studies of the State Board of Health, was selected as chief engineer.

Subsequent changes in the commission and its officers as well as of its successors, the Metropolitan Water and Sewerage Board and the present Metropolitan District Commission are shown later in this paper.

Additions to Territory. — Successive Legislatures have added certain districts to the original area. Chapter 406 of the Acts of 1895 provided for the Neponset valley system, comprising parts of the West Roxbury and Dorchester Districts of the city of Boston, together with the towns of Dedham, Hyde Park* and Milton. The total area of this district amounts to 39.57 square miles, of which about 17 square miles form the southerly portion of the original main drainage district of the city of Boston, previously referred to. This entire system was originally connected by gravity with the Boston Main Drainage Works at Granite Avenue, in Dorchester, but is now tributary to the outfall off Nut Island via the high-level sewer, except about two square miles in Dorchester and Milton which still discharge through the Main Drainage Works. By chapter 414 of the Acts of 1896, the southerly portion of the town of Wakefield 0.95 square miles in extent, was added to the north metropolitan sewerage district. In like manner, by chapter 520 of the Acts of 1897, the town of Lexington was authorized to connect the sewerage systems of its central and eastern villages with the north metropolitan sewers, making a further addition of 5.11 square miles to the metropolitan sewerage district.

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* Since 1912 a part of Boston.

A more important addition of areas under the jurisdiction of the commission was effected in 1899, involving the construction, by that body, of the high-level sewer which had been foreshadowed, in 1875, as a feature of the Boston Main Drainage System. The conditions anticipated at the time when the Boston low-level system was designed had long been exceeded by the growth of the sewered area within the city, while the addition of the Charles River and Neponset valley districts made further large demands upon the capacity of the Boston works. Heavy and increasing rentals were being paid by the Commonwealth to the city of Boston for the partial use of the city system, including the cost of pumping; and in 1898 the sewerage commissioners reported to the Legislature.as to the growing need of relief, following this up, in 1899, by recommending the construction of a high-level sewer with an independent gravity outfall into the harbor, off Nut Island, Quincy. The Legislature gave effect to this recommendation by chapter 424 of the Acts of 1899. This added important districts in Roxbury, West Roxbury and Dorchester of the city of Boston, and the whole of the city of Quincy, representing an addition to the south metropolitan sewerage district of 20.98 square miles. Chapter 172 of the Acts of 1900 provided for the construction of a branch sewer for the central portion of the town of Wakefield and added 6.70 square miles to the area of the north metropolitan sewerage district. Chapter 242 of the Acts of 1903 provided for a gravity sewer outlet for the sewage of the whole town of Revere and added 5.86 square miles to the north district. Chapter 343 of the Acts of 1914 provided for a gravity sewer outlet for the town of

Wellesley, connecting with the Neponset valley sewer and increased the area of the south district by 9.89 square miles. Chapter 159 of the Acts of 1916 provided for the addition of the town of Reading to the north district, increasing the area by 9.82 square miles and authorized the construction of an outlet sewer to connect with a main trunk sewer in the Mystic valley.

Present Territory. — At the present time the north metropolitan sewerage district comprises 100.32 square miles and the south metropolitan sewerage district 110.76 square miles, a total of 211.08 square miles.

Other legislation has provided for various extensions of the sewers, for repairs to the East Boston Pumping Station after the disastrous fire in Chelsea on April 12, 1908, and the explosion in the old screen-house chamber of June 1, 1914, due to gasolene vapor in the entering sewer, for additional pumping plant at Deer Island, East Boston and Ward Street Pumping Stations, and new screening plant at East Boston Station, extension of

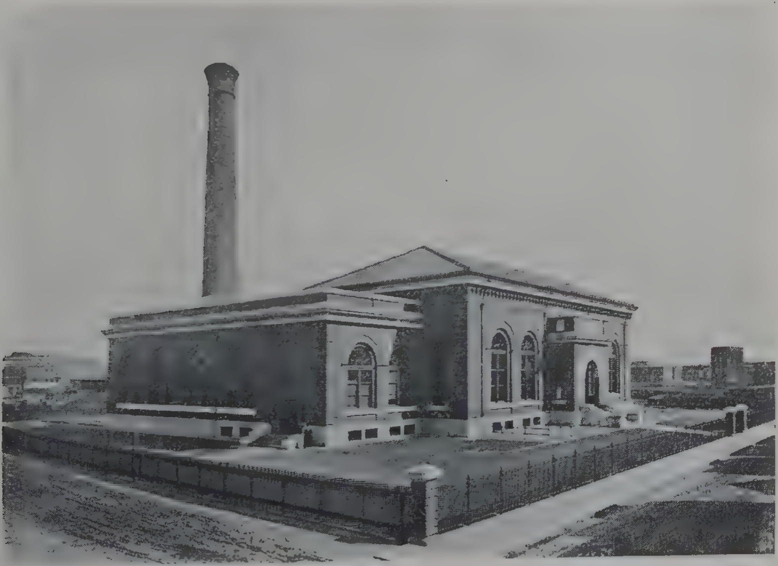


FIG. 3. — WARD STREET PUMPING STATION.

the Deer Island Outfall and the building of an additional outlet at Nut Island, construction of the Hough's Neck (Quincy) Sewage Lifting Station, lowering the Malden River Siphon to provide a channel 20 feet deep, investigation of sewage disposal of Arlington and Lexington, and the addition of the town of Braintree to the south metropolitan sewerage district whenever so voted by the town.

The Metropolitan Water and Sewerage Board created by chapter 168, Acts of 1901, took over all "powers, rights, duties and liabilities" of the Board of Metropolitan Sewerage Commissioners on March 20, 1901. The Metropolitan District Commission created by chapter 350 of the Acts of 1919 took over all the "powers, duties and responsibilities" of the Metropolitan Water and Sewerage Board and the Metropolitan Park Commission on December 1, 1919.

In accordance with the provisions of section 126 of said chapter the Commissioner, the Hon. James A. Bailey of Arlington, organized four divisions; namely, Parks, Park Engineering, Water and Sewerage and appointed Frederick D. Smith of Malden, Chief Engineer and Director of the Sewerage Division.

CONSTRUCTION OF THE METROPOLITAN SEWERAGE WORKS

Charles River Valley System

The construction of the Charles River valley system was begun in May, 1890, soon after the organization of the original board. With work of this magnitude difficulties were frequently encountered, especially in the more thickly settled districts and where natural conditions of soil were unfavorable. However, such difficulties merely caused delays, and the work on the system progressed rapidly until its completion in the spring of 1892, when it was at once put into operation.

It provides an outlet for the local sewers of Waltham, Watertown, most of Newton, Brighton (part of Boston), most of Brookline and part of the Back Bay District of Boston, and was designed to meet the prospective conditions in 1930, including an estimated population of 183,000, for which a sewer capacity at the rate of 30 cubic feet per head per twenty-four hours was provided. This represents a maximum rate of flow equal to 64 cubic feet per second. The system consists of 8.1 miles of intercepting sewer in a single line. Commencing in Waltham as a 3 foot 6 inch by 4 foot sewer, it becomes by successive enlargements 6 feet 6 inches in diameter at the lower end where the invert level is about 5 feet below mean low water. The rates of inclination of this system are 1:1,500 for the 3 foot 6 inch by 4 foot sewer and 1:2,500 for the larger sizes. Originally designed to be tributary to the Boston Main Drainage Works with which it was connected at the intersection of Huntington Avenue and Gainsborough Street, Boston, it was, upon the completion of the High-Level Sewer, connected therewith at the corner of Vancouver and Ruggles Streets, Roxbury, in the summer of 1904 and shortly afterwards in 1905 and 1906, the flow of sewage in that portion lying between the above connecting-point and the last connection from local sewers into it at Bryant Street was reversed by building a new concrete invert about 3 feet in diameter within the old one, for a distance of about 1,860 feet with an inclination towards Vancouver Street of 1 foot in 1,500 feet.

Below the Bryant Street connection a 40-inch penstock valve has been introduced at the end of the modified invert. From Bryant Street to Gainsborough Street the Charles River main sewer, here 6 feet 6 inches in diameter, was cleared of deposit and washed and the exclusion valve at Gainsborough Street closed. This leaves an abandoned sewer between Bryant Street and Gainsborough Street 1,600 feet in length and filled with ground water, which could be used, if necessary, for turning the flow of the Charles River main sewer into its old connection with the Boston Main Drainage Works or the City of Boston Works could find similar relief in case of accident, through the South Metropolitan System.

North Metropolitan System

Construction upon the north metropolitan system was carried on simultaneously with that of the Charles River, but, owing to the greater magnitude of the work, was slower in progress and much later in its completion. During the five years required to complete the system as originally authorized no delays of a serious nature occurred. Such portions of the work as were thought too important to entrust to contract labor, or which involved possible changes of design to meet conditions as they arose, were constructed by day labor under the direct superintendence of the engineering force employed by the Board. These included that part of the outfall sewer in the main channel off Deer Island, various crossings under streams, and the construction of large pump-wells connected with the four pumping plants. The three main pumping stations were all in operation in the summer of 1895, and the whole system has been in operation since the early part of 1896.

The north metropolitan system consists of a main line and several branches, with a present total length of 66.803 miles. Of the latter, the Cambridge branch is the most important. An anticipated volume of sewage on the basis of 30 cubic feet per head per twenty-four hours was provided for in the original design except in Cambridge and Somerville, where the sewerage systems were mainly of the "combined" type and in many cases below tide level. For these two cities a basis of 35 cubic feet per head was adopted. At present we design for 300 gallons per head per twenty-four hours and to exclude storm water. For an estimated population of 571,000 in 1930 these allowances yield in the aggregate a maximum flow at the rate of 210 cubic feet per second. Our estimated population contributing is now 588,430.

Commencing in Reading, about 20½ miles from Deer Island light, after crossing the divide by means of a force main from Reading Pumping Station and passing down through the valley in Stoneham, the main line follows the valley of the Aberjona River, sometimes spelled Abbajona, to a point below Winchester, and continues thence, along the line of the old Middlesex canal, to a point near the dam between the upper and lower Mystic lakes. Here it is joined by the old Mystic valley sewer, built in 1877 and 1878 by the city of Boston to prevent the pollution of the upper lake, at that time one of the sources of the city water supply. Part of this old sewer was purchased by the commissioners and adopted as a local branch, to take the sewage of the greater part of Woburn (through the Cummingsville branch) and a section of Winchester. About 350 feet below the intersection with the Old Mystic sewer the main sewer is joined by the New Mystic sewer built in 1912, 1913 and 1914 as an additional main sewer in the valley, running from Woburn through Winchester and a part of Medford.

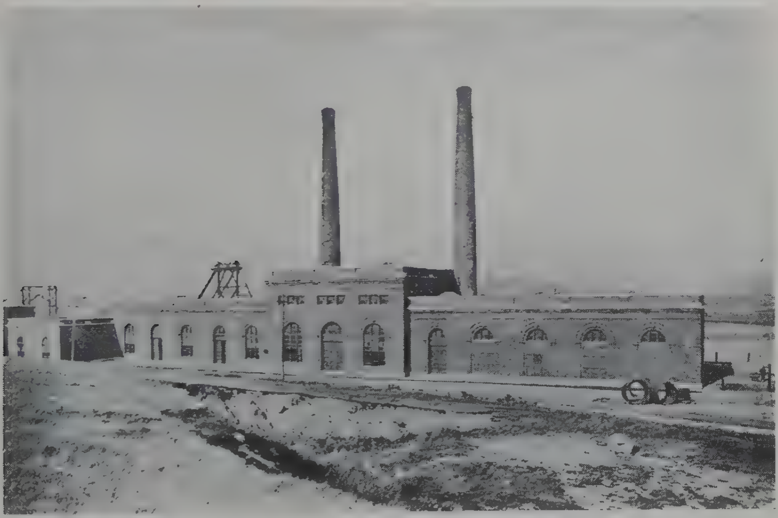


FIG. 4. — EAST BOSTON PUMPING STATION.

The metropolitan sewer continues down the valley, alongside the southern division of the Boston & Maine Railroad, to West Medford. It there receives the Alewife Brook branch, contributing sewage which has been lifted about 13½ feet, at the Alewife Brook pumping station, from Belmont, Arlington and Lexington, as well as from low-lying areas of Cambridge, Somerville and Medford. Continuing through Medford, it is joined at Wellington village, in the eastern section of that city, by the Edgeworth branch, carrying the sewage of the westerly section of Malden. On leaving Wellington, the metropolitan sewer passes under the Malden River by an inverted siphon, and is joined near West Everett railroad station by the branch from East Stoneham, Wakefield, Melrose, part of Everett and the larger part of Malden. About three-quarters of a mile farther on, near the Everett railroad station, it is joined by the discharge sewer, into which the sewage from Cambridge, Somerville, Charlestown and parts of Medford have been pumped by the Charlestown Pumping Station, and which takes by gravity the sewage from a small part of Everett. It then passes through Chelsea and along a part of the water front, where it is joined by branches intercepting the sewage from the easterly section of Chelsea, parts of Everett and Revere.

The main sewer then passes by a siphon under Chelsea Creek to the East Boston pumping station, where the whole volume of sewage, with the added contribution of the East Boston intercepting system (built by the commissioners), is lifted about 15 feet. Continuing through East Boston and Breed's Island, it passes under Belle Isle Inlet by three parallel siphons, traverses the town of Winthrop, and is then carried under the navigable strait known as Shirley Gut by yet another siphon to Deer Island, where a pumping plant lifts the sewage to such elevations averaging 11.4 feet in the past year, as are required by the fluctuations of the tide. The discharge sewer from this station follows the western shore to the southern end of the island, and is then carried about 1,860 feet into the harbor by a masonry outfall sewer to the original outlet (now closed) and through 322 feet of 84-inch cast iron pipe extension to the point of discharge at about 50 feet below low water. The outfalls, both old and new, were designed for the continuous discharge of sewage, without any provision for storage during the period of incoming tide or longer, for, having regard to the favorable geographical position of the selected outlet, and to the velocity of the current into which the sewage is discharged, storage was not considered necessary. The continuous operation of the works for many years with the old outlet has amply confirmed the correctness of this decision.

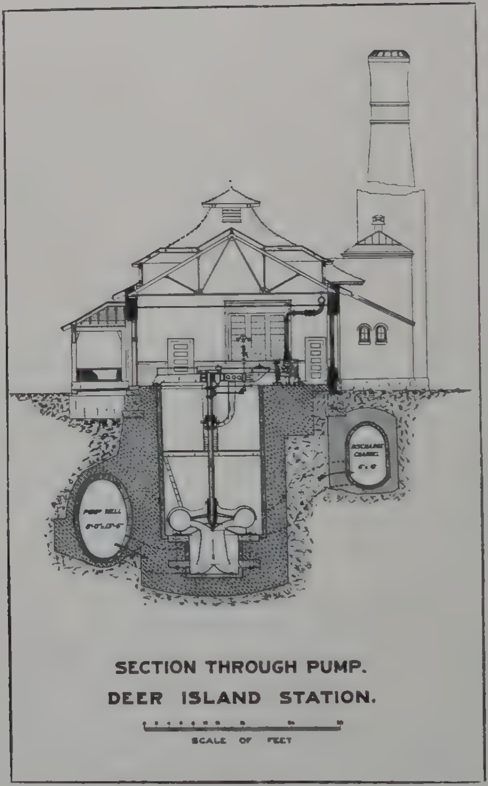
Cambridge Branch. — The upper end of the Cambridge branch was originally in the westerly section of that city, about 15 miles distant from the Deer Island outlet, and about 6½ miles from its junction with the main line near Everett station. It follows generally the line of streets in the vicinity of the Charles

River, at a sufficient depth to pass below and intercept the sewers formerly discharging into the river. In Sullivan Square, Charlestown, it receives the Charlestown branches, and about a quarter of a mile further on is joined by a branch draining parts of Somerville and Medford. The sewer then passes by a siphon under the Mystic River to a pumping station on the opposite bank, where the sewage is lifted about 8 feet into the high-level discharge sewer, previously referred to. This branch was extended to the Cambridge-Belmont boundary line by 4,780 feet of 24 inch by 28 inch brick sewer and 1,587 feet of 22 inch by 28 inch brick sewer in 1903 and 1904. Many features of interest, both in design and construction, were developed by the necessities of the north metropolitan system. Some of these are referred to below.

The excavation of the sewer trenches was attended, in places, with much difficulty, owing to the unfavorable character of the sub-soil, especially by the occurrence of so-called quicksands. Along the water fronts and elsewhere the progress of the work was seriously impeded by this obstacle, it being found practically impossible, by ordinary methods, to free the excavation from the volume of boiling sand forced up by the pressure of water lying several feet below the construction plane. Tubular wells were sunk at frequent intervals into the water-bearing stratum, and connected, in the trench, by horizontal piping, leading to a steam pump. In this way the head of water above the bottom of the trench was sufficiently lowered to prevent the forcing up of sand, and operations were carried on as in ordinary excavation. This method was successfully used on several sections of the work.

Tunnels under the Mystic River and Chelsea Creek and in quicksands in deep excavation were worked by the aid of air-locks. Pressures up to about 18 pounds per square inch, in excess of the atmosphere, were maintained in the working lengths. The method of supporting the tunnel roof in quicksand was by means of a needle-bar and curved steel plates.

Shirley Gut Siphon. — At the point selected for the crossing of the north metropolitan main sewer, Shirley Gut is 315 feet wide at mean high water, with a depth of 25 feet of water in the middle. The tidal current practically never ceases; it is so swift that the building of a temporary timber bulkhead across the strait was necessary before commencing work on the inverted siphon. The construction adopted for the pipe was essentially novel. Six sections of riveted tank-steel shell, $\frac{3}{8}$ of an inch thick,



SECTION THROUGH PUMP.
DEER ISLAND STATION.

FIG. 5.

8 feet 5 inches in diameter, with a total length of 264 feet, were constructed on the beach and lined with three rings of Portland cement brickwork, leaving the internal diameter of the tube 6 feet 2 inches. Two of these sections were short man-hole specials; the others varied from 48 feet to 68 feet in length, and

weighed, when lined and bulkheaded in readiness for floating, from 80 to 112 tons each. They were so curved as to form a depression of 22 feet in the axial line of the completed work. The separate sections were closed by strong timber bulkheads, furnished with valves, and floated at high water alongside of scows provided with hoisting gear. They were partially filled with water through the valves, and lowered singly into a trench previously dredged for their reception, where they rested upon sills which had been accurately set by divers. The sections were afterwards bolted together by divers, the bulkheads removed and the water pumped out through the man-hole sections, thus enabling the short lengths of brickwork to be built inside. The interior was finally lined very smoothly 1¼ inches thick with Portland cement mortar rammed into place, five elm-hoop furrings 1½ inches wide by ¼ inch thick, soaked in hot paraffine and fastened with heavy copper rivets, being used in this work for each linear foot of siphon.

Deer Island Outlet. — In the laying of the original 6¼ foot outfall sewer to a point abreast of Deer Island light, 1,860 feet beyond the shore line at high water, two methods were adopted. The shore end of the work, for a length of 674 feet, was constructed by excavation within a coffer-dam. Beyond this point recourse was had to a modification of the system adopted at Shirley Gut, built-up timber lagging being used instead of steel shells. The sewer was formed of separate sections, each about 52 feet long. Instead of building these on the beach, they were constructed on specially designed timber cradles built at each side of a pier, erected by the commissioners in connection with the Deer Island pumping station. The cradles were suspended from a system of gearing operated by a portable engine, capable of raising or lowering the cradle and sewer sections uniformly throughout. The sewer sections were built of 4-inch spruce lagging, lined with 6 inches of concrete and 8 inches of brickwork. The work was carried on as in an ordinary sewer trench, the invert being first constructed and the arch then turned on centres. The completed lagging was then surrounded with strong oak hoops at intervals of two feet, and the two ends bulkheaded. The weight of each section, ready for floating, was about 95 tons. After the cradle had been lowered into the water by the gearing, the sewer section was floated out and towed to its position over a dredged trench, and lowered by travelling shears running on a temporary pilework. It was then bolted by divers to the work already in position, and a back-filling of gravel over the whole length completed the external work. The gaps in the brickwork lining were subsequently filled up from the inside. The whole of the outfall sewer was constructed by day labor. The greatest diameter of the north metropolitan sewers is 9 feet 1 inch and the least gradient 1:3,250.

Pumping Plants at Deer Island, East Boston and Charlestown. — The pumping plants for the two main line stations (Deer Island and East Boston) and for the Cambridge branch (Charlestown) consisted at first of two pumping engines, with the necessary boilers, piping, etc. An additional engine and boilers of the same general type as those originally installed have been erected at each of these stations. Each engine at the Deer Island and East Boston stations is capable of easily raising 70 cubic feet of sewage per second 19 feet vertically above the level of the sewage in the pump well, and of raising to greater heights, up to 25 feet, quantities of sewage inversely proportional to such lifts. It is also capable of pumping at as low a rate as 15 cubic feet per

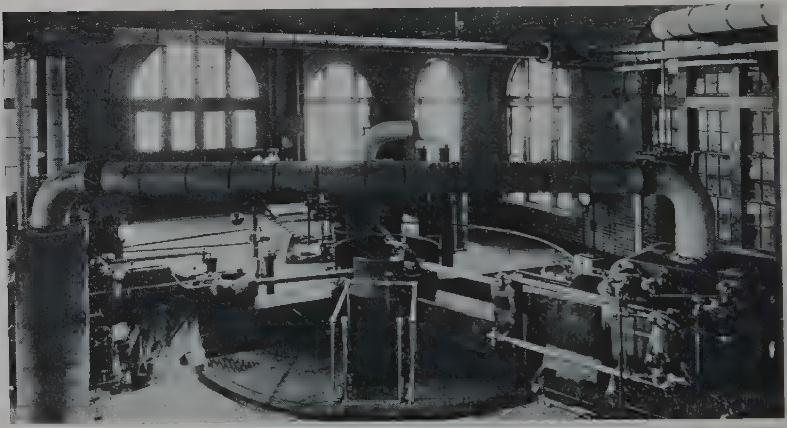


FIG. 6. — ENGINE AT DEER ISLAND PUMPING STATION.

second, and at all rates between that and the maximum rate of 70 cubic feet. The pumps are of the centrifugal type, with vertical shafts. The pump wheels, 8 feet 3 inches in diameter, run at speeds varying from 60 to 100 revolutions per minute according to the volume of sewage and the height to which it is lifted. Each pump wheel is driven by a triple-expansion condensing engine of the Reynolds-Corliss type, the three cylinders being set at angles of 60°, in order to give uniform turning movement on the crank. The cylinders are 13½, 24 and 34 inches in diameter, with 30 inches stroke. In the Charlestown pumping station the capacity of each of the original two engines is 35 cubic feet per second, raised 11 feet high, with similar provisions as to varying height. The pump wheels are 7 feet 6 inches in diameter. The cylinders are 9¼, 16½ and 23 inches in diameter, with 30 inches stroke. The third engine has an impeller wheel 8 feet 3 inches in diameter and a capacity of 93 cubic feet per second, raised 8 feet high. These pumping plants are of special design, and were built and erected by the Edward P. Allis Company of Milwaukee, Wis. In the contract duty and capacity tests to which the three plants were subjected, taking the mean of the first two engines installed in each case, the duty developed was 94,814,724, 91,781,682 and 89,723,074 foot-pounds at Deer Island, East Boston and Charlestown respectively. The efficiencies of the centrifugal pumps (W. H. P. divided by I. H. P.) were respectively 62 per cent, 57 per cent and 52 per cent. In the capacity tests of the third engines an excess over the aggregate of work required was developed in each case and in the coal-duty trials the duties specified in the contracts have in all three stations been exceeded. A 100,000,000-gallon pump with 19 foot lift of the same general type as the three earlier ones was installed at Deer Island in 1910 and another of similar capacity at East Boston in 1911. Both successfully passed the contract tests, with an excess over the required duty.

Neponset Valley System

The Neponset valley system originally consisted of a single line of sewer, 11.30 miles in length, of which 1.24 miles, being part of the Dorchester interceptor of the Boston Main Drainage

System, was purchased by the Commonwealth from the city of Boston. The head of the system was in the West Roxbury section of Boston, where the sewer is 12 inches in diameter. It gradually enlarges, until in the lower part of Hyde Park, at the intersection with the high-level sewer, its size is 4 feet 6 inches by 4 feet 7 inches. From this point its size is mainly 3 feet by 4 feet, the permanent function of the reduced cross-section being to deal only with the sewage of the area lying east of the high-level sewer, as shown on the general map. The sewer capacity for the permanent conditions was based upon a maximum flow equal to 30 cubic feet per head per twenty-four hours, on an estimated 1930 population of 213,000, or at the rate of 74 cubic feet per second. The least gradient here is 1 foot in 2,000 feet.

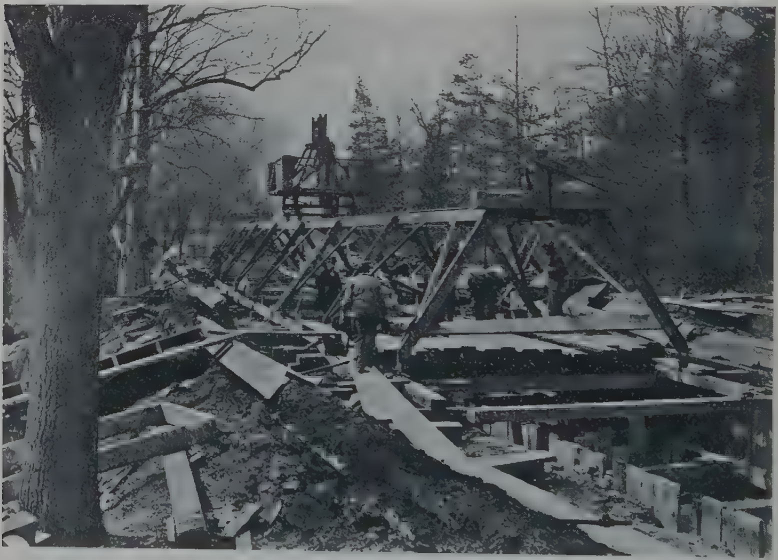


FIG. 7. — TRENCH MACHINE.
High Level Sewer.

This system was extended in 1901 from a point in St. Joseph's Cemetery, West Roxbury, through a part of Newton to the Brookline town line at a point midway between Newton and La Grange Streets, a total distance of 6,718 feet — 2,356 feet is of 24 inch brick sewer and the remainder of 18 inch and 15 inch pipe sewers. Excavation was in sand, gravel and sandy clay with an average depth of 9 feet, and a small amount of rock was encountered.

South Metropolitan District

High-Level Sewer. — The legislative act in 1899 authorizing the construction of the high-level sewer dealt with the Charles and Neponset River Areas, already under the jurisdiction of the Metropolitan Sewerage Commission, together with new high-level territory. These were grouped into a new district, embracing all the metropolitan areas south of the Charles River, together with Watertown and Waltham, north of the river, to be known as the South Metropolitan Sewerage District. This area and the leading data of the works are shown on the general map. The object of the undertaking was to provide for as large a portion of the district as possible by gravity, leaving the remainder to be dealt with by pumping. After the construction of the high-level sewer, the sewage of the Charles River valley, until then discharged into the Boston Main Drainage System at Gainsborough Street, was diverted to the Ward Street pumping station, erected near Huntington avenue in Roxbury and there raised about 40 feet into the high-level system. The high-level sewer receives at various points, by gravity, the sewage from important areas of Boston, and intercepts in the same way nearly all the drainage of the Neponset Valley area. The city of Quincy is also tributary to the high-level system, partly by pumping and partly by gravity.

The sewer capacities for the high-level system are based upon the anticipated conditions in 1940, which include a population of 986,000. A rate equal to 300 gallons per head per twenty-four hours was adopted, to cover all contingencies likely to arise. Applied to the estimated population, this represents a maximum flow of 458 cubic feet per second in 1940.

The conduit for conveying the sewage from the Charles River system to the Ward Street pumping station is 6 feet 6 inches by 7 feet and about 680 feet long. The two cast-iron force mains, of 48-inch pipe, from the Ward Street pumping

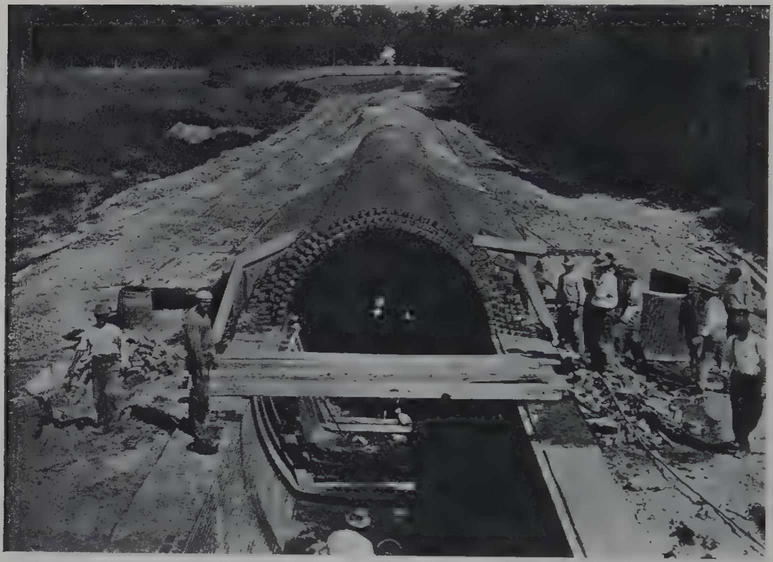


FIG. 8. — SEWER IN FILLED EMBANKMENT.
High Level Sewer.

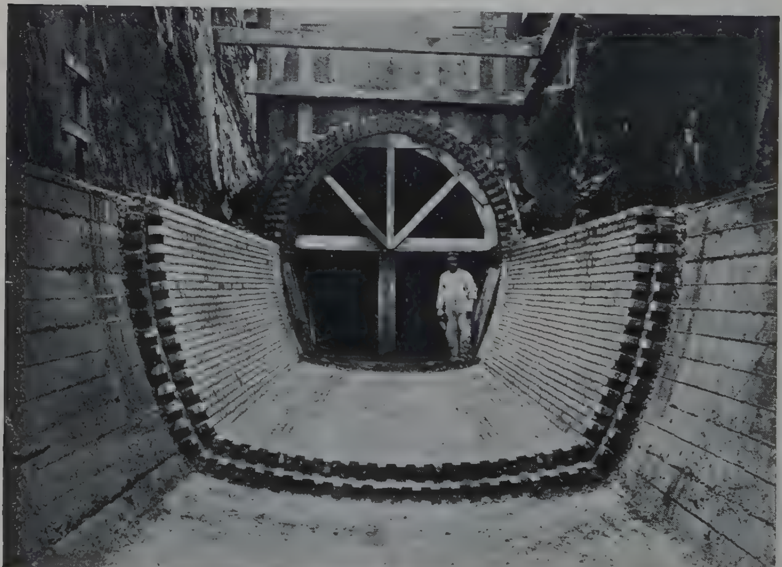


FIG. 9. — SEWER IN ROCK CUT.
High Level Sewer.

station deliver at 34 feet above mean low water into a 6 foot 6 inch by 7 foot sewer, 5,060 feet long, extending to a point near Perkins Street in West Roxbury, where the invert elevation is about 31½ feet above mean low water. At this point a high-level sewer for the more elevated areas of Newton, Brighton and Brookline is connected. The latter was constructed in 1907, 1908 and 1909 and is 5.64 miles in length.

The necessary increase in size brings the dimensions of the main line sewer below the junction to 8 feet 3 inches by 9 feet 2 inches. The sewer passes on the east side of Jamaica Pond, following the west side of the Stony Brook valley. It is carried in rock tunnel through the divide to the easterly end of Hyde Park, where the Neponset valley metropolitan sewer is intercepted. The sewage of several small districts in Dorchester and Milton included in the Neponset River valley system, which are too low for sewage to be delivered into the high-level sewer by gravity, is, under an arrangement with the city of Boston, disposed of through the Boston Main Drainage Works at Moon Island. By this arrangement the Commission is relieved from the expense of providing extra pumping facilities.

The course of the sewer to Quincy is then through the valleys of the Pine Tree and Unkety brooks, in Milton; it passes through Quincy as an 11 foot by 12 foot 3 inch and 11 foot 3 inch by 12 foot 6 inch sewer to Nut Island, where its invert elevation is about 10 feet above mean low water. The total length of the main line of sewer is about 16 miles and its slope from Roxbury to Nut Island is 1:3,500. At Nut Island there is a screen-house and sand-catcher from which the two original 60 inch diameter outfall pipes of heavy cast-iron extend out into the harbor a distance of over a mile and discharge at the bottom of the channel at points 1,500 feet apart, into a depth of about 30 feet of water at low tide.

An emergency relief outfall, also of 60 inch cast-iron pipe, about 1,500 feet long was laid in 1914. The depth over this outlet is about 20 feet at low water. No discharge is made from this outlet except at flood periods.

Nut Island Outlet. — The 60 inch cast-iron pipes for the outfalls were purchased under separate contracts from those

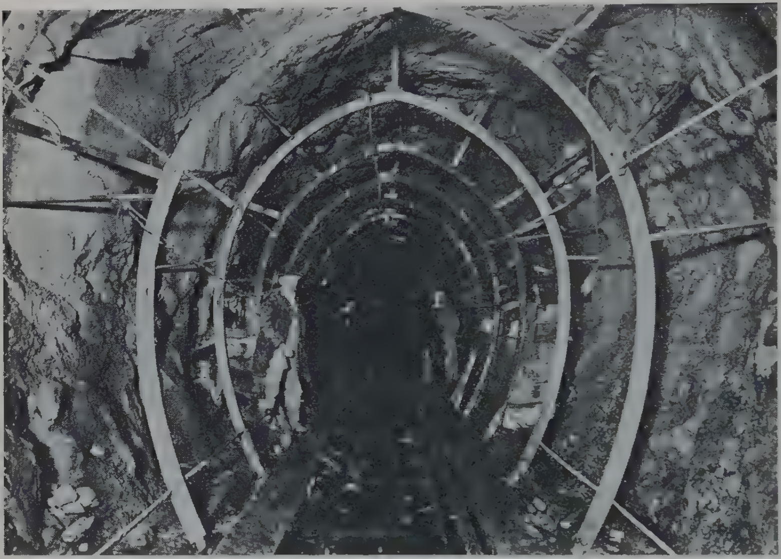


FIG. 10. — STEEL RIBS IN PLACE.
High Level Sewer.

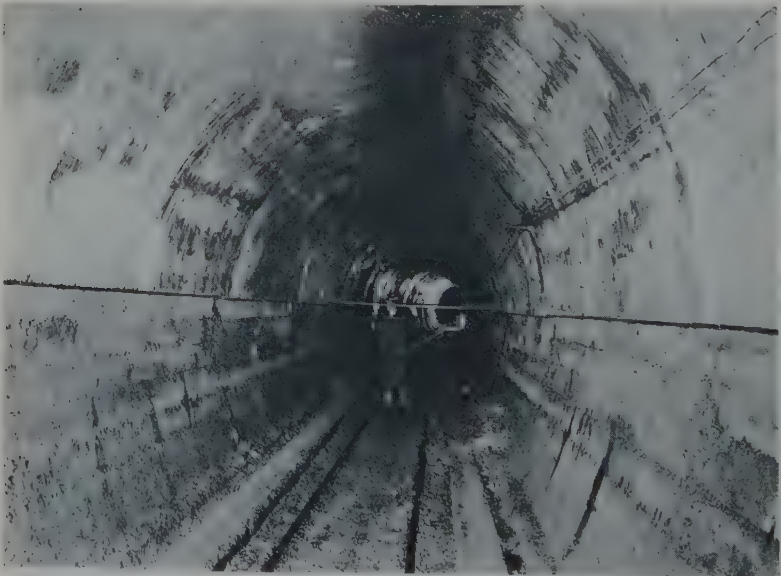


FIG. 11. — CONCRETE SEWER IN ROCK TUNNEL.
High Level Sewer.

made for the dredging, laying, etc. The pipes are spigot and socket pipes, 1½ inch thick, weighing 6 tons per standard twelve-foot length. The dredging was begun on July 17, 1902, for the westerly line, which was laid first.

The bottom of the pipes have an average depth of about 9 feet below the bed of the harbor, and the trench was dredged 2 feet deeper, to a maximum of 53 feet below mean high water. The bottom of the trench was 10 feet wide, and the sides sloped so as to give a mean top width of 30 feet. The dredging was in stiff clay. In this trench ten-foot piles were driven in five-foot bents of two piles each, at intervals of 6 feet. These were capped by spruce timbers set to the required grade, thus insuring two points of support for each pipe. The piles were driven with the assistance of a vertical telescopic guide box, 35 feet long when closed, resting upon the bed of the harbor, and capable of adjustment to varying depths of trench and conditions of the tide. In this contrivance, which was designed by the contractor, a cylindrical hammer, 10 feet long, descended upon a pile placed within the inner box. A 75-foot lighter was used for the pile-driving work.

The pipes were laid in 48-foot sections, consisting of three lengths of ordinary spigot and socket pipes and one length having the spigot turned to a slight taper for a length of 5½ inches. This spigot was temporarily inserted, upon the wharf, into the bell of a pipe which was to form the leading end of a section, and the lead space entirely filled with lead, but without calking. The spigot was then withdrawn, to be used as the rear end of the following section. The four pipes forming a section were then arranged, in their proper order, upon a floating caisson, lashed to the side of a second lighter, the three ordinary joints being run and calked in the ordinary manner. The caisson was a heavy timber structure, of a special design patented by the contractor, 6 feet square outside and 52 feet long, built of 6-inch hard pine and divided by eight transverse bulkheads into nine compartments, which could be separately flooded. On one face of the caisson eight timber saddles, shaped to the external contour of the pipes, served as a resting place for the pipe section, which was firmly secured by chains and turnbuckles. When filled with water the caisson was sufficiently heavy to sink, but when empty its flotation was sufficient to support a section weighing about 24 tons. On being released from the lighter, the caisson immediately turned over, so that the pipes were suspended from it in the water. Then, through openings controlled by plugs, the compartments were sufficiently flooded to sink the whole. Arriving at the bottom, and still attached to the caisson, they were adjusted by divers to line and grade upon the caps, and the tapered spigot was drawn home into the leaded bell of the preceding section by means of ratchet-jacks, actuated by levers. For the latter purpose the leaded bell was temporarily fitted with a collar, provided with four guides to ensure the entry of the tapered spigot without damage to the lead mould. When the pipes were finally secured in position by wedges spiked to the pile caps, the caisson was filled with water, thus rendering it too heavy to float, and released from the completed section. It was then hauled to the surface by steam-

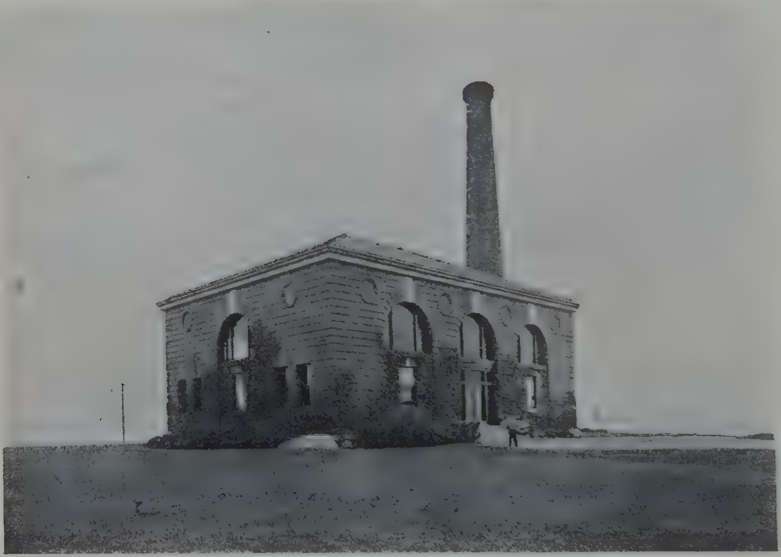


FIG. 12. — NUT ISLAND SCREEN HOUSE.

winches on the lighters, and the water forced out of the compartments by an air-pump. The special joint between the sections was calked before the excavated material was deposited from scows in the trench and over the pipes.

The work was begun at the outlet, which consisted of a special quadrant bend, about 11 feet in length and weighing nearly 11 tons, the thickness of metal being 2½ inches. The outlet pipe was surrounded by a rectangular timber casing 13 feet square and 10 feet deep, projecting 2 feet beyond the extreme dimensions of the pipe and filled with Portland concrete. It rested upon 12 piles, 22 feet long, and was surmounted and surrounded by a cut granite ring, 30 inches deep, in six pieces. Piling beyond the casing served as a framework for a timber curbing, the interior space being covered by 18-inch slab paving laid upon coarse gravel filling, with its surface sloping from the top of the granite ring, which was about 2½ feet above the harbor bed and 34 feet below high water. The pipes were laid in strong tidal currents, due to a mean tidal range of 10 feet, which prevented continuous diving work. The ordinary rate of pipe laying in working weather was about 100 feet per week. The maximum rate during any week was 300 feet, and this was maintained during a number of weeks.

New Mystic Sewer. — The New Mystic sewer was authorized in 1912 as an additional main sewer in the Mystic Valley extending from a point near the boundary line between Woburn and Winchester and running through Winchester and a part of Medford to a point in the Metropolitan main sewer on the easterly side of the Boston & Maine Railroad at a distance of about 353 feet below the bell-mouth at the intersection of the main sewer and the Old Mystic sewer. About 1,663 feet of the total length of about 3.4 miles were built in tunnel and the remainder in open cut of an average depth of 15 to 20 feet. The sewer is of concrete increasing in size from 24 inch by 36 inch (oval) cross-section at the upper end by 36 inch, 42 inch, 48 inch and 54 inch diameter circular cross-sections to the lower end. No excessive amount of ground water was encountered and the natural foundation provided for the sewer was good except for short distances where a pile foundation was necessary. The crossing of the Aberjona River was effected by means of two lines of 20-inch cast-iron pipe surrounded by concrete and laid on the grade of the sewer. The work was completed in 1914.

*Extension of Deer Island Outlet.** — The extension of the outfall at Deer Island, from its original location about 200 feet west of Deer Island Light, where the sewage had been discharged continuously from the first operation of the north metropolitan system in 1895, to a point in deep water 322 feet farther south by means of 84-inch diameter cast-iron pipes and special castings was begun in 1915.

The original outfall was on the southerly slope of Deer Island Bar, about 1,900 feet from the Deer Island mainland and about 3,500 feet from the Deer Island pumping station, where the sewage was lifted to elevations sufficient to discharge it continuously against the varying tidal head. The outlet was one-half foot below mean low water and discharged vertically upward. The general direction of flow was toward the main ship channel, where strong currents tended to dissipate the sewage rapidly.

This outfall was placed at a time when such method of sewage disposal was practically untried. on a large scale, but had proven successful in so far as pollution of the shores was concerned. There had always been discoloration of the water in the ship channel for some distance, perhaps one-half mile, about the outfall. The outfalls of the South Metropolitan System, placed about nine years after that at Deer Island, are thirty feet below low water. The condition of the harbor water had been so much better around these outfalls that the Metropolitan Water and Sewerage Board sought to improve the North Metropolitan System outfall by a similar submergence, with the added improvement of multiple outlets.

Complaints about the condition of the water surrounding the Deer Island outfall had been made by boating interests,

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* *Editor's Note.* — A paper describing the Extension of Deer Island Outlet, presented before the Sanitary Section of the Boston Society of Civil Engineers on January 3, 1917, by Clarence A. Moore, Assistant Engineer, Metropolitan Water and Sewerage Board, was published in the *Journal of the Boston Society of Civil Engineers*, Vol. IV, No. 3, March, 1917. Although a considerable portion of the data concerning this extension was presented at that time, it has seemed advisable to include it also in this paper in order that the information concerning the Metropolitan Sewerage Works may be complete.

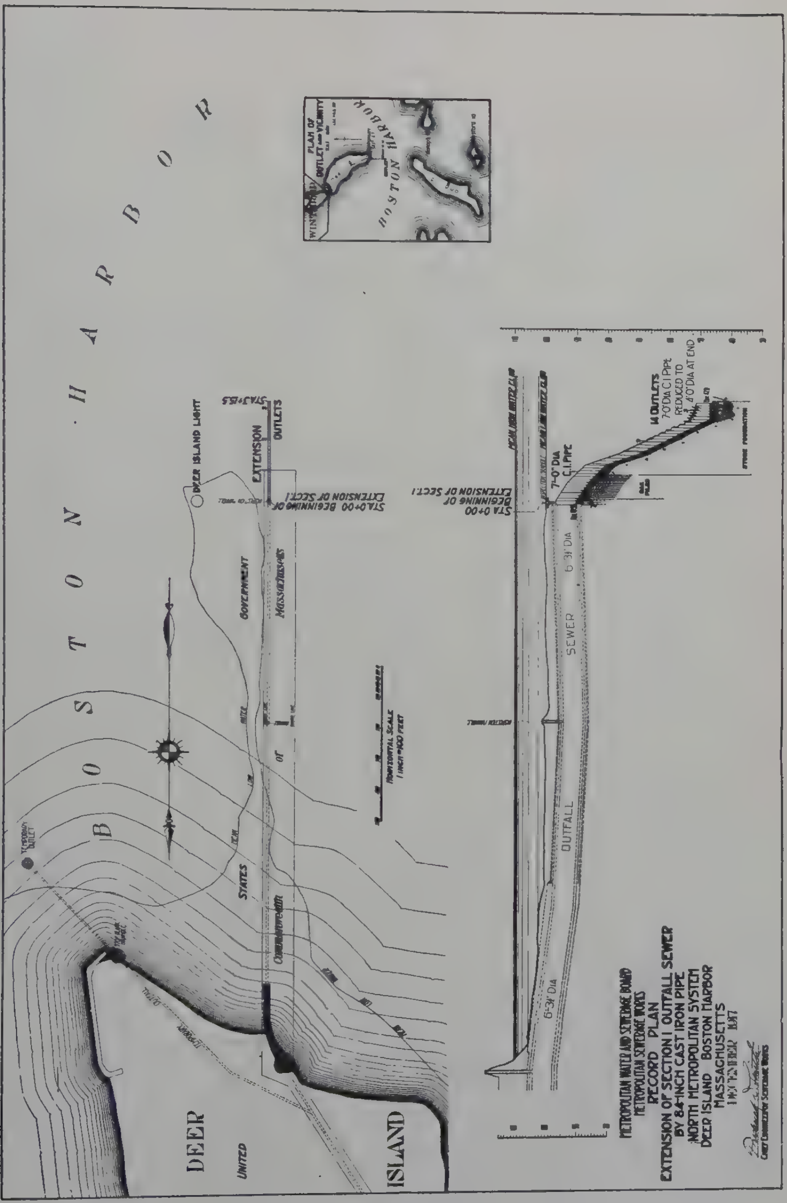
BOSTON HARBOR
DEER ISLAND
UNITED STATES GOVERNMENT
COMMONWEALTH OF MASSACHUSETTS
DEER ISLAND LIGHT
EXTENSION
OUTLETS
STA.3+15.5
STA.0+00 BEGINNING OF EXTENSION OF SECT.1
TEMPORARY OUTLET
PLAN OF OUTLET AND VICINITY
BOSTON HARBOR
WINTHROP
HORIZONTAL SCALE 1 INCH = 400 FEET
STA 0+00 BEGINNING OF EXTENSION OF SECT.1
7'-0" DIA C.I. PIPE
14 OUTLETS 7'-0" DIA C.I. PIPE REDUCED TO 4'-0" DIA AT END
STONE FOUNDATION
6'-3½' DIA
OUTFALL SEWER
6'-3½' DIA
METROPOLITAN WATER AND SEWERAGE BOARD
METROPOLITAN SEWERAGE WORKS
RECORD PLAN
EXTENSION OF SECTION 1 OUTFALL SEWER
BY 84-INCH CAST IRON PIPE
NORTH METROPOLITAN SYSTEM
DEER ISLAND BOSTON HARBOR
MASSACHUSETTS
1907
CHIEF ENGINEER OF SEWERAGE WORKS

FIG. 13. — GENERAL PLAN AND LAYOUT — EXTENSION OF DEER ISLAND OUTFALL.

also by officials of the United States government in view of the proposed use of the south end of Deer Island for military purposes, and because of the proximity of the Deer Island lighthouse, a structure not in existence when the original outfall was designed.

For the first step a temporary outlet had to be provided so that the sewage flow might be diverted during the construction of the extension of the permanent outfall. This temporary line was started at a point on the existing outfall sewer about 200 feet back from the high-water line on Deer Island. Here a double-chambered stop-plank manhole was built, the chambers extending to the bottom of the old sewer and a new branch was cut into it at an angle of 30 degrees.

From this manhole a 6 foot 6 inch circular sewer of reinforced concrete was built following in a general way the southerly shore-line of the island for a distance of about 770 feet. From a second manhole, located where this 6 foot 6 inch sewer ends, 400 feet of 60-inch cast-iron pipe was laid partly in open, hand-excavated trench and partly in dredged trench. A 90-degree bend forms the outlet of this line, the opening being upward and some three feet below mean low water. This line was studied and designed with the expectation that it would at some time be extended to a point where the water is forty-five feet deep. With this provision of two outlets the advantage of distributing the sewage over a considerably larger area will be gained.

Dredging was commenced July 9, 1916, in preparation for the extension of the old line. As no dipper dredge which could work to the required depth was available, the work was accomplished with orange-peel and clam-shell buckets. The material removed was almost entirely coarse gravel although a little blue clay was encountered near the lowest depth reached. Dredging was continued along the center line of the trench, no particular attention being given to the side slopes until sufficient depth was obtained.

An area 64 feet by 20 feet was dredged to about 58 feet below low water, the outer end of this area being about 322 feet south of the old outfall. From this area the trench extended back to the existing outlet, the depth being such that

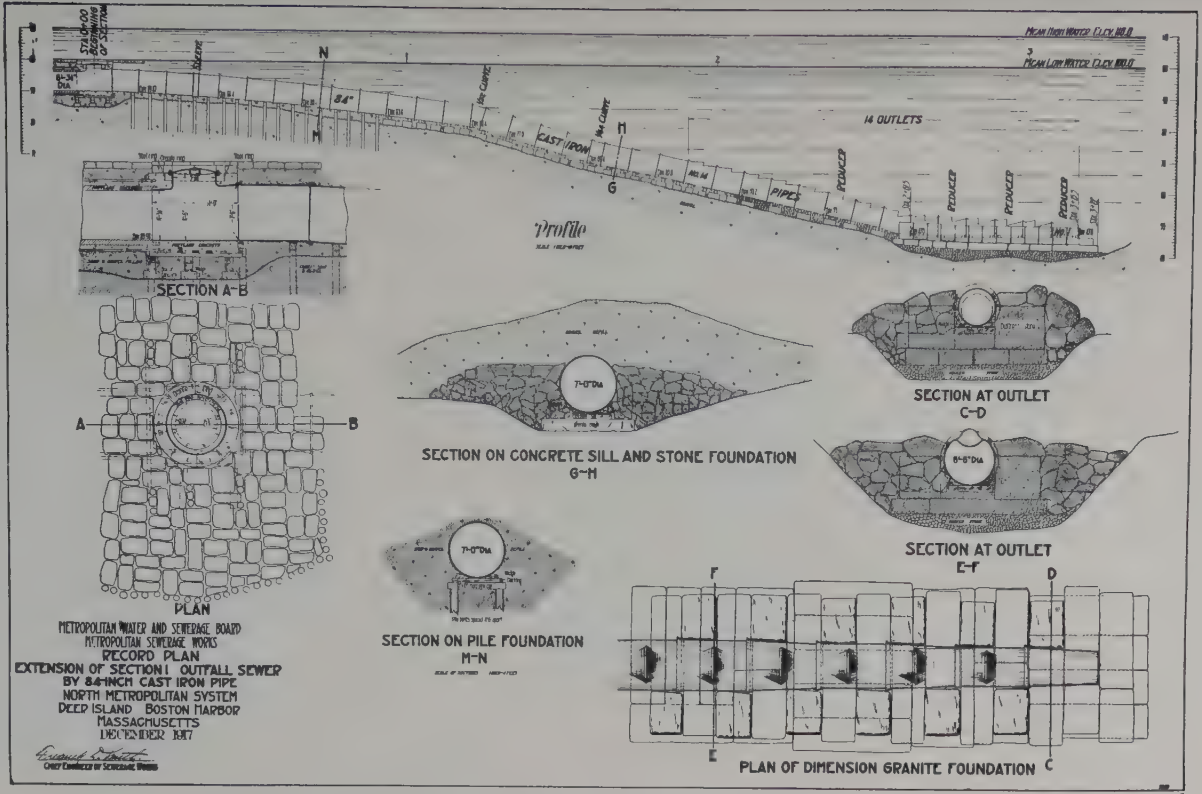
Mean High Water Elev. 110.0
Mean Low Water Elev. 100.0
STA. 0+00 BEGINNING OF SECTION
84" DIA.
SLEEVE
N
M
84"
1/32 CURVE
1/64 CURVE
CAST IRON
H
G
14 OUTLETS
PIPES
REDUCER
REDUCER
REDUCER
REDUCER
Profile
SECTION A-B
A
B
PLAN
7'-0" DIA.
SECTION ON CONCRETE SILL AND STONE FOUNDATION
G-H
SECTION AT OUTLET
C-D
8'-6" DIA.
SECTION AT OUTLET
E-F
7'-0" DIA.
SECTION ON PILE FOUNDATION
M-N
F
E
D
C
PLAN OF DIMENSION GRANITE FOUNDATION
METROPOLITAN WATER AND SEWERAGE BOARD
METROPOLITAN SEWERAGE WORKS
RECORD PLAN
EXTENSION OF SECTION 1 OUTFALL SEWER
BY 84-INCH CAST IRON PIPE
NORTH METROPOLITAN SYSTEM
DEER ISLAND BOSTON HARBOR
MASSACHUSETTS
DECEMBER 1917
CHIEF ENGINEER OF SEWERAGE WORKS

FIG. 14. — TYPICAL DETAILS — EXTENSION OF DEER ISLAND OUTFALL.

reëstablishment of the original surface conditions after the pipe was in place would leave the pipe slightly covered to a point on the pipe a little north of the first outlet opening. From this point to the outer end, the grade of the pipe brings it gradually above the sloping ground. The water-line of the pipe at the extreme end is about fifty-four feet below low water.

In the sloping trench for a distance of 54 feet northerly from the level area described, single stones 6 feet to 7½ feet long by 4½ feet wide by 2 feet thick were laid firmly on the gravel bed of the trench as a foundation for each pipe. Two concrete sills 8 inches by 12 inches by 6 feet were set upon each of these stones to adjust the pipe to required grade.

From this point to the old outfall, pile bents of two piles each were used. The piles were driven 3 feet each side of center line of the pipe. The bents were 4 feet 6 inches apart and were capped with 10 inch by 10 inch yellow pine timber. The change to pile foundation was due to the fact that the dredged trench became hardly more than a level bench on the side of the slope. It was considered that the piles would afford a more secure support against lateral sliding.

Over the level area at the south end mentioned above a layer of granite chips was placed between stations 2+58 and 3+22 to even up irregularities left in dredging. On this bed granite blocks 2 feet in thickness were placed. Most of these blocks are from 12 to 15 feet long by 4 feet 6 inches to 5 feet wide. Some few are more nearly square measuring about 9 by 7 feet by 2 feet thick.

On this foundation course a second course of dimension granite blocks 2 feet thick was placed. The stones in this course are so laid that the outer ends of adjacent stones are near opposite sides of the lower course and the inner ends overlap under the pipe forming a continuous layer. In this way spaces were left on either side of the pipe between alternate stones into which buttress stones 6 feet by 5 feet 6 inches by 4 feet were fitted. These buttress stones placed against the pipe just back of the bells secure the pipe against any lateral or longitudinal movement. The three outer buttress stones on the east side of the pipe location were set before the pipe was placed.

The 84-inch pipe, with specials, were furnished under contract and were brought to South Boston by rail, lightered to the Deer Island shore and landed on the beach at high water. The pipes, which are in 9-foot lengths, are 2 inches thick and have bells 6 inches deep. The standard pipes weigh about 17,000 pounds each. The heaviest piece, a reducing tee 75 inches by 84 inches by 75 inches and 11 feet long, which made the connection with the original structure, weighs 24,980 pounds. Twenty-three of these pipes, including all those having outlet openings, were coated externally with "Bitumastic" enamel while on the Deer Island shore. The object of this treatment was to protect the more directly exposed pipe from the action of salt water.

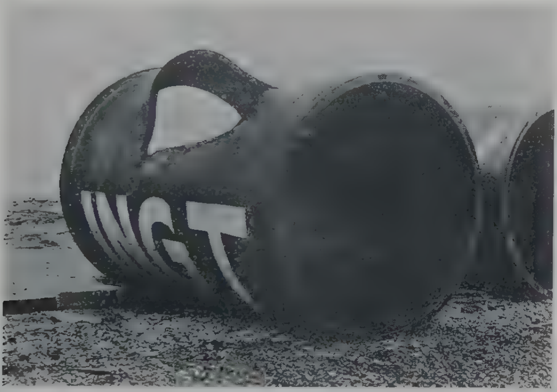

FIG. 15. — TYPICAL OUTLET PIPE.
Extension of Deer Island Outfall.

To lay the pipes, six at a time were taken aboard the lighter of the contractor and made together on blocking into three-pipe sections, the joints being leaded. These sections were handled by being slung from a strongback in straps of wire rope by the derrick boom of the lighter.

In placing the sections, the lighter was secured to permanently established mooring lines and drawn into position above the prepared foundation. The pipe was then lowered on to the concrete sills placed by the divers, adjusted to required grade and securely blocked. The outermost two sections were placed in this manner on the heavy stone foundation and the remaining buttress stones were set in position.

The third section, consisting of two straight pipes and a curve, as may be seen from the profile, extends beyond the heavy stone foundation described and is laid with considerable slope, about 1 to 4½. It was obvious that, to lay the pipe on this slope without danger of displacing the sills, the pipe must be lowered in a sloping position so that the spigot end could be inserted in the bell of the previously laid pipe before the other end came to a bearing. To accomplish this, the contractor provided a special strongback formed of two 15-inch steel channels riveted together with separators between. Three hanger plates were riveted to the sides of each channel and to these hangers were attached straps of wire rope. In slinging the pipe, the free end of these straps was hooked into the eye of a turnbuckle suspended from the hanger at the other side of the strongback. This afforded a very convenient method of tightening the straps.

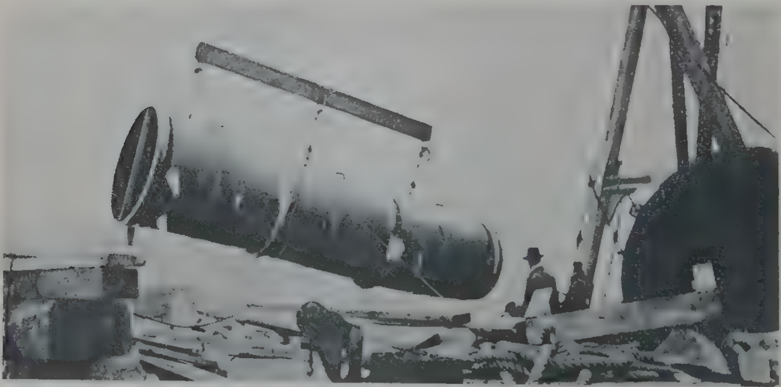

Fig. 16. — Method of Laying Outlet Pipe on a Slope.
Extension of Deer Island Outfall.

Near either end of the strongback was a pin 3 inches in diameter around which was passed an endless, heavy wire cable. The two strands of this cable passed through a yoke, the position of which could be adjusted before the apparatus was brought under tension. Under tension, the yoke was clamped rigidly in position. By trial, the position of this yoke was so established as to give the required slope to the pipe and the suspended section was then lowered to place.

The joints between the sections were calked by the divers with lead wool with ordinary calking tools. A strip of lead cast 6 inches wide by ½ inch thick and of sufficient length to extend around about one-third the perimeter of the pipe was placed in the lower part of the bell of each slip joint. This served to keep the spigot end up in alignment and to reduce the amount of calking required at the most difficult part to reach. In addition to the lead so placed, each joint required about 150 pounds of lead wool and consumed about two days' time for completing the calking. One diver would usually be calking joints while the other was at work preparing the foundation to receive another section. During the period of strongest tidal current, when material could not be lowered, both divers worked on the joints.

Owing to the exposed location of this work, there was necessarily much lost time. The unusually stormy spring and summer with much foggy weather was especially unfavorable, and work other than dredging was not started until about September 20, 1916. The swift currents and frequent heavy undertow encountered in this location rendered the placing of material other than rough stone for riprap work impossible except at slack water on days when there was no considerable undertow.

When it became necessary to suspend work on account of winter weather conditions, four sections of pipe (108 feet) had been placed. Two of these sections were laid on the heavy stone foundation with but little slope and the other two were laid on the incline. Blocks of broken granite and granite chips had been placed under and around these pipes and between the buttress stones forming a defense extending about twenty feet on either side of the center line and rising to the general grade of the top of pipe. No backfilling was done about that portion of the line where the fourteen outlets are located with any fine material which might be washed from place. The inshore end of the pipe and the three outlet openings in the section last laid were bulkheaded to prevent filling with gravel during the winter.

Work was resumed in the summer of 1917, the pipe laying was continued toward the existing outlet on a pile bent foundation to the point where the sleeve is shown. The existing outfall was broken out and the reducer "tee" 75 inches by 84 inches by 75 inches was connected into the existing channel. The branch was capped and the pipe extended to meet the pipe laid from the outer end. The closure was made with a sleeve, two pipes having both ends spigots being utilized for this purpose. The construction was completed on December 3, 1917.

The discharge under the new conditions is from fourteen outlet openings increasing in size toward the outer end. The diameters of these openings, which are approximately elliptical with the exception of the outermost which is a 48-inch circle, vary from 25 by 44 inches to 13 by 23 inches, respectively. The reduction from 84 inches to the 48-inch terminal outlet is accomplished in seventy-two feet by making alternate pipe into reducers, the reduction in each being nine inches.

The design of the pipe was determined as the result of studies for different conditions of tidal head and flow. The areas of the several openings are proportioned so as to discharge as nearly equal quantities as possible.

While the sewage will inevitably come to the surface, due to the difference between its specific gravity and that of sea water, the expectations that the greater opportunity for dissipation and dilution before the surface is reached with this scheme of distributed discharge under a considerable depth of water, would result in materially improved appearance of the water about this portion of the harbor have been fulfilled.

At present the sewage of the north district is being discharged wholly through this new outlet and the temporary outlet off the southeasterly shore of Deer Island, used during its construction, is closed by means of a cast-iron cover which can, however, be easily removed when necessary.

Note. — An examination by diver was made of the outfalls in 1922. Those on the south line were found to be clear of deposit and in excellent condition. The outfall near the Deer Island light was in good condition, but there was considerable deposit in the outer portion of the discharge pipes.

One of the discharge openings was found to be entirely choked with grease. These obstacles were all removed. Apparently this type of outfall is going to need more attention than those originally designed.

Removal of Aberjona River Siphon. — The 24-inch siphon which crossed the Aberjona River near Wedgemere Station and which was built by the city of Boston in connection with the construction of the old Mystic Valley Sewer was removed in 1918 at the request of citizens of Winchester. A connection was made between the old Mystic Valley Sewer and the Metropolitan trunk sewer at Station 4+55 of Section 44 of the latter and that part of the old Mystic Sewer between this point and the location of the siphon has been discontinued.

Reading Extension. — In 1916 the town of Reading was admitted to the North Metropolitan Sewerage District. An extension of the north metropolitan sewer, with a daily capacity of 4,000,000 gallons, has been built from a point in Hill Street, Woburn, through parts of Woburn and Stoneham, paralleling

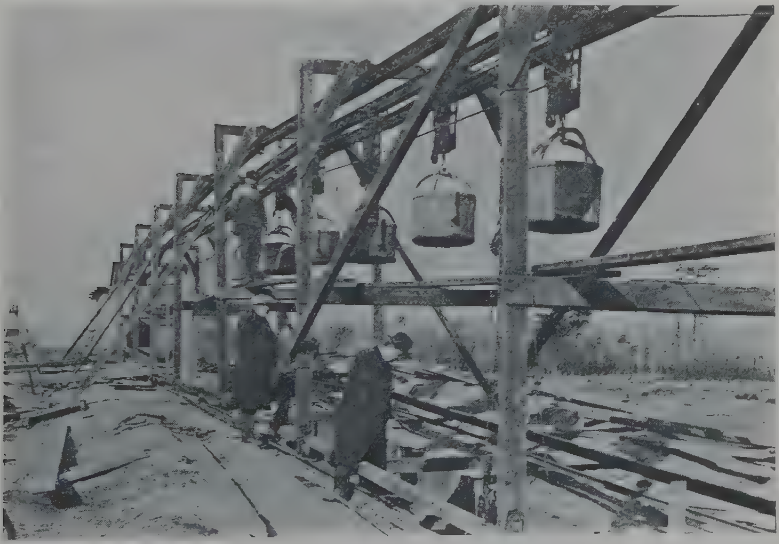

FIG. 17. — TRENCH MACHINE.
Reading Extension.

the old sewer for about $\frac{1}{2}$ mile and then through Stoneham and Wakefield and a corner of Reading to a point in Brook Street, Reading, near the Wakefield and Reading Boundary line. Work on this line was begun at the Reading end in 1918 and about 1,400 feet of concrete sewer of 24 inch by 27 inch and 36 inch circular cross-section built from that point to the crossing of Summer Avenue. As originally planned a gravity line was contemplated with a tunnel through the ridge for some 6,000 feet, commencing at Summer Avenue, but on account of the impossibility in war time of doing this for anywhere near the amount of the appropriation made for this work, the plans were changed and a covered concrete receiving reservoir was built at this point connected with a pumping station (on the projecting corner of Reading above mentioned) at which the sewage can be raised a maximum height of about 65 feet through a 16 inch cast-iron force main about 1,370 feet in length and emptied into the upper end of a gravity sewer consisting of 15 inch, 18 inch and 20 inch pipe at Hopkins Street, Wakefield, from which point it flows to the connection with the old main sewer in Hill Street. The reservoir and the concrete sewers between it and the connection with the Reading Main Sewer have a combined storage capacity of about 250,000 gallons. The 36-inch inlet sewer along the easterly side of the reservoir, the reservoir and the pump well were all constructed of concrete and largely in rock, the rock excavation ranging in depth from 18 to 36 feet. A small amount of ground water was encountered.

The pipe sewers were laid by contract in an average earth cut of 7 feet. Considerable water had to be taken care of in the trenches of the upper half of the line.

The pumping station has been erected and the machinery installed by the regular maintenance engineers, machinists, mechanics and laborers of the Sewerage Division.

The station is equipped with two submerged centrifugal pumps of 2,500,000 and 4,000,000 gallons per twenty-four hours capacity with vertical shafts directly connected to 75 H.P. and 100 H.P. motors, respectively.

Alternating current is supplied from the Reading Municipal Plant, entering the station at 440 volts. Average pumping per twenty-four hours is about 750,000 gallons at the present time.

This plant was put into operation in December, 1921. Some details of the reservoir construction are as follows: Horse-shoe section, interior dimensions: length, 100 feet; height, 18 feet; width, 20 feet. Including the pump well and foundations, 2,870 cubic yards of rock were excavated and 1,280 cubic yards of concrete were placed.

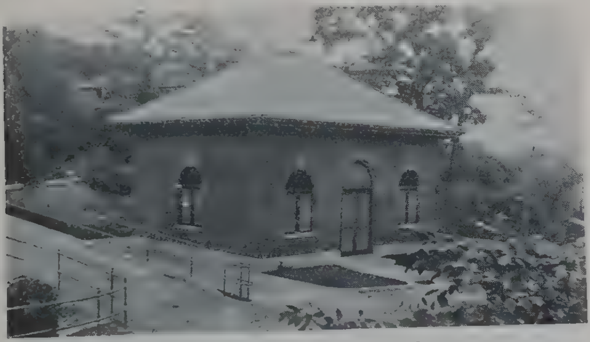

FIG. 18. — READING PUMPING STATION.

The total cost of constructing the Reading extension has been about $314,000 up to the present time.

Wellesley Extension. — Chapter 343 of the Acts of 1914 provided for the admission of Wellesley into the South Metropolitan District and for the construction of a trunk sewer connecting the town with the Neponset Valley Sewer of the High-level System. The Act was not accepted by the town until March, 1915, when surveys and detailed plans were started. The original estimate for the construction of $350,000 was made by the State Board of Health and was based on a report submitted by an engineer called in by that department to make a survey and estimate. Two lines were considered by the Board of Health. The estimate was made on the shorter line which came through the location of the Brookline Water Works fields. This line was to connect with the existing Neponset Valley Sewer at a point where the sewer has a capacity suitable only for the original district for which it was built.

Because of the small size of this existing Metropolitan sewer and the fact that this line extended across the Water Works fields and would interfere with this important supply and also because of the fact that there is a rapidly growing portion of Dedham in the vicinity of Bridge Street which is a part of the Metropolitan Sewerage District and had no possible means of reaching the Metropolitan System except by construction work done by the Metropolitan Board, it was decided to use the alternate line proposed by the State Board of Health. This line was somewhat longer but reached the existing Metropolitan sewer at a point where the latter is of increased size and at the same time furnished a means of outlet for the above mentioned portion of Dedham and obviated the difficulties in connection with construction in the fields of the Brookline Water Works.

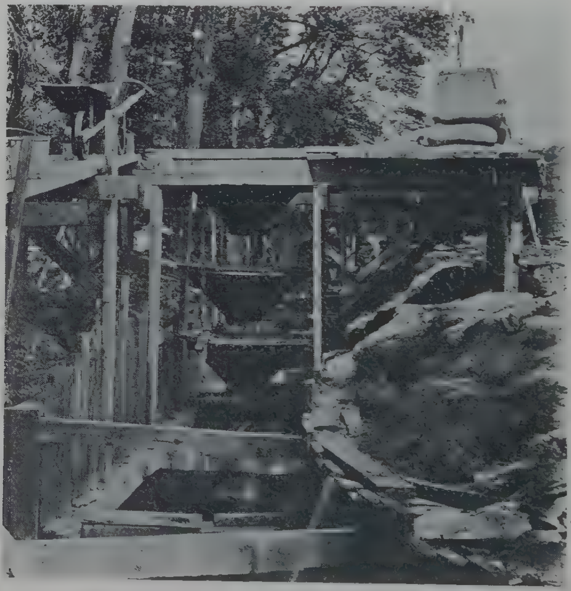

FIG. 19. — GRAVITY CONCRETE MIXER.
Wellesley Extension.

A sewer of considerably larger capacity than was anticipated by the State Board of Health was designed as it was felt that the future demands of the District justified so doing.

The line adopted has a length of about 40,000 feet almost wholly through private lands. The natural physical conditions in this part of the Charles River Valley made sewer construction very expensive. This was caused by the large amount of rock encountered, by the fine sands and other material in which it was difficult to construct and by the remoteness of the location of the work. Above all, the abnormal conditions of the market in regard to labor and supplies, as occasioned by the recent war, increased the cost of the work.

Starting at station 22+39 of Section 26, Neponset Valley sewer in West Roxbury, the line extends in a westerly direction across the Charles River into Dedham and follows in this portion in a general way the line proposed by the State Board of Health as an alternate line, crossing Bridge Street and Pine Street and again crossing the Charles River. It then continues in Dedham through private lands till it again approaches the said river, thence it extends along its southern bank crossing Greendale Avenue and Dedham Avenue. Near the latter it again crosses the Charles River into the town of Needham and extends along the northerly side of the river and in a general way parallel to said river through private lands crossing Chestnut Street, South Street and the New York, New Haven & Hartford Railroad about 500 feet west of Charles River Station, continuing in private lands and crossing Central Avenue and Charles River Street and extending to a point in private land in the town of Wellesley about 10 feet north of the Needham-Wellesley town line.

The sewer was constructed of concrete, except at the river crossings, where cast-iron pipes were used, and varies in size from 24 inches by 27 inches at the Wellesley end of the line to 36 inches by 40 inches at the lower end. It was largely built in open trench of a depth of from 7 to 15 feet except for about 930 feet of 27 inch by 36 inch concrete sewer in rock tunnel at an average depth of 26 feet below the surface at Charles River Village in Needham and about 1,300 feet of 33 inch by 36 inch concrete sewer in rock tunnel at an average depth of 25 feet below the surface in and near Jenney Lane in Dedham. In this latter tunnel a brick arch was substituted for the concrete arch as planned at the request of the contractor. This was permitted as it reduced the cost of the work.

The contractor for one of the sections undertaken in the year 1917 found difficulties in carrying out his contract so serious on account of the loose, wet, fine sands that he felt obliged to abandon the work before any permanent construction of the sewer had been effected. The Board then took over the work under the oversight of a sewer builder of much experience and the undertaking was successfully carried on under great difficulties and completed, but at a very large increase in expense over the contract price.

Borings along the line of the proposed sewer were made in the usual manner and samples of the materials found in the borings were exhibited to those who proposed to bid for the work, but even experienced contractors misjudged the probable behavior of these materials and the cost of the work far outran the estimates.

The progress was necessarily slow as the sewer extended across the marsh through which the Charles River runs and at certain periods of the year this marsh was overflowed and the work had to be abandoned for a time. About 700 feet of the work constructed on this section required a pile foundation and for 2,300 feet of the remainder it was necessary to drive 3-inch matched sheeting to a depth of from seven to nine feet below grade much of the way and build the concrete sewer on a gravel platform. The average cut for this section was about 15 feet and the sizes of the concrete sewer 36 inches by 40 inches and 34 inches by 37 inches. Considerable ground water was encountered.

The Wellesley Extension was completed and opened for the use of the town in July, 1921. The total cost of the construction was about one million dollars.

PUMPING STATIONS

North Metropolitan System

Deer Island Pumping Station. — At this station are four submerged centrifugal pumps with impeller wheels 8.25 feet in diameter, driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of 1 pump: 100,000,000 gallons, with 19-foot lift.
Contract capacity of 3 pumps: 45,000,000 gallons each, with 19-foot lift.

East Boston Pumping Station. — At this station are four submerged centrifugal pumps, with impeller wheels 8.25 feet in diameter, driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of 1 pump: 100,000,000 gallons with 19-foot lift.
Contract capacity of 3 pumps: 45,000,000 gallons each, with 19-foot lift.

Charlestown Pumping Station. — At this station are three submerged centrifugal pumps, two of them having impeller wheels 7.5 feet in diameter, the other 8.25 feet in diameter. They are driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of 1 pump: 60,000,000 gallons with 8-foot lift.
Contract capacity of 2 pumps: 22,000,000 gallons each, with 11-foot lift.

Alewife Brook Pumping Station. — The plant at this station consists of two 9-inch Andrews commercial centrifugal pumps, direct connected by horizontal shafts to compound marine engines, together with a pump and engine added later. The latter consists of a specially designed engine of the vertical cross-compound type, having between the cylinders a centrifugal pump rotating on a horizontal axis.

Contract capacity of the 2 original pumps: 4,500,000 gallons each, with 13-foot lift.
Contract capacity of 3rd pump: 13,000,000 gallons, with 13-foot lift.

Reading Pumping Station. — At this station are two submerged centrifugal pumps of 2,500,000 gallons per 24 hours, and 4,000,000 gallons per 24 hours, capacity. These operate against a maximum head of 65 feet, and are actuated by vertical shafts directly connected with 75 and 100 horsepower motors. Alternating current of 440 volts furnished by the municipal plant of the town of Reading is used.

Plant opened for use	December 7, 1921
Average gallons pumped per 24 hours	750,000

South Metropolitan System

Ward Street Pumping Station. — At this station are two vertical, triple-expansion pumping engines, of the Allis-Chalmers type, operating reciprocating pumps, the plungers of which are 48 inches in diameter with a 60-inch stroke. Each pump with the boilers, engine, piping, etc., cost about $100,000.

Contract capacity of 2 pumps: 50,000,000 gallons each, with 45-foot lift.

Quincy Pumping Station. — At this station are two compound condensing Deane pumping engines and one Lawrence centrifugal pump driven by a Sturtevant compound condensing engine.

Contract capacity of 3 pumps: Deane, 3,000,000 gallons; Deane, 5,000,000 gallons; Lawrence centrifugal, 10,000,000 gallons.
Average lift, 26.07 feet.

Quincy (Hough's Neck) Sewage Lifting Station. — At this station are two 6-inch submerged Lawrence centrifugal pumps with vertical shafts actuated by two Sturtevant direct-current motors.

The labor and electric energy for this station are supplied from the Nut Island screen-house, and as used at present it does not materially increase the amount of coal used at the latter station. The effluent is largely ground water.

Contract capacity of 2 pumps: about 1,500,000 gallons each, with 20-foot lift.
Average daily amount pumped: 224,300 gallons. Average lift, 15.19 feet.

Nut Island Screen-House. — The plant at this house includes two sets of screens in duplicate actuated by small reversing engines of the Fitchburg type. Two vertical Deane boilers, 80 horse power each, operate the engines, provide heat and light for the house, burn materials intercepted at the screens, and furnish power for the Quincy (Hough's Neck) sewage lifting station.

Average daily quantity of sewage passing screens: 67,000,000 gallons.

Capacities and Results

The following table shows the comparison of the growth in the amount of sewage handled and the total cost of the operation of the different stations in 1921 with the same items of 1920 and of 1914 when prices had not been affected by the war:

PUMPING STATION.	SEWAGE PUMPED IN 1921 INCREASED OVER THAT OF —		COST OF OPERATION IN 1921 INCREASED OVER THAT OF —	
	1920.	**1914.**	**1920.**	**1914.**
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Deer Island	7*	17	3*	113
East Boston	7*	17	9*	83
Charlestown	6*	19	8*	62
Alewife Brook	11*	31	8*	49
Quincy	2*	45	27*	64
Ward Street	3*	25	22*	65

* Decrease.

Average Daily Volume of Sewage lifted at Each of the Six Principal Metropolitan Sewerage Pumping Stations and at the Quincy (Hough's Neck) Sewage Lifting Station during the Year, as compared with the Corresponding Volumes for the Previous Year.

PUMPING STATION.	AVERAGE DAILY PUMPAGE.			
	Jan. 1, 1921, to Dec. 31, 1921.	Jan. 1, 1920, to Dec. 31, 1920.	Decrease during the year.	
	Gallons.	Gallons.	Gallons.	Per Cent.
Deer Island	68,600,000	74,000,000	5,400,000	7.3
East Boston	66,600,000	72,000,000	5,400,000	7.5
Charlestown	38,900,000	41,400,000	2,500,000	6.0
Alewife Brook	4,591,000	5,156,000	565,000	11.0
Quincy	5,776,000	5,918,000	142,000	2.4
Ward Street (actual gallons pumped)	33,333,000	34,261,000	928,000	2.7
Quincy (Hough's Neck) sewage lifting station.	224,300	225,600	1,300	0.6

SUMMARY OF METROPOLITAN SEWERAGE WORKS

There are now 118.113 miles of metropolitan sewers. Of this total, 9.642 miles of sewers, with the Quincy pumping station, have been purchased from cities and towns of the districts. The remaining 108.471 miles of sewers and other works have been constructed by the metropolitan boards.

Of the estimated gross population of 1,131,990 on December 31, 1921, — 963,390, representing 85.1 per cent, were on that date contributing sewage to the metropolitan sewers through a total length of 1,503.21 miles of local sewers owned by the individual cities and towns of the districts.

The maintenance of the metropolitan sewerage system includes the operation of 8 pumping stations, the Nut Island screen-house, and 118.113 miles of metropolitan sewers receiving the discharge from 1,503.21 miles of town and city sewers at 473 points, together with the care and study of inverted siphons under streams and in the harbor.

Applications for connections with the sewers are entertained only from the governments of the various cities and towns.

Efforts to improve the condition of the metropolitan sewers in regard to dangers resulting from the introduction of gasolene into the same are being continually made.

An inspector is employed whose duty it is to visit existing garages and see that the separators are kept in proper condition; also to enforce the regulation concerning the installation of such separators at all newly constructed garages.

During the year 1921 the average flow through the North Metropolitan District outfall at Deer Island was 68,600,000 gallons of sewage per 24 hours, with a maximum rate of 151,200,000 gallons during a stormy period in July. The amount of sewage discharged in the North Metropolitan District averaged 117 gallons per day for each person, taking the estimated population of the district contributing sewage. If the sewers in this district were restricted to the admission of sewage proper only, this per capita amount would be considerably decreased.

In the South Metropolitan District an average of 67,000,000 gallons of sewage passed daily through the screens at the Nut Island screen-house, and was discharged from the outfalls into the outer harbor. The maximum rate of discharge per day which occurred during an exceptionally stormy period in May was 178,000,000 gallons. The discharge of sewage through these outfalls represents the amount of sewage contributed by the South Metropolitan District, which was at the rate of 179 gallons per day per person of the estimated number contributing sewage in the district.

The daily discharge of sewage per capita is considerably larger in the South Metropolitan District than it is in the North Metropolitan District, because, owing to the large size and unused capacity of the south district high-level sewer, more storm water is at present admitted to the sewers of this district.

The material intercepted at the screens at the North Metropolitan sewerage stations, consisting of rags, paper and other floating materials, during the year amounted to 1,346.6 cubic yards. This is equivalent to 1.45 cubic feet for each million gallons of sewage pumped at Deer Island.

The material intercepted at the screens at the South Metropolitan sewerage stations amounted to 3,180.2 cubic yards, equal to 3.51 cubic feet per million gallons of sewage delivered at the outfall works at Nut Island.

The total cost of constructing the —

North Metropolitan System to the end of 1921 =	$7,572,580
South Metropolitan System to the end of 1921 =	9,904,868
Total	$17,477,448

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Special Report of the Metropolitan Sewerage Commissioners upon a High-Level Gravity Sewer for the Relief of the Charles and Neponset River Valleys, including reports by Joseph P. Davis, Consulting Engineer, William M. Brown, Jr., Chief Engineer to the Commissioners, and H. W. Clark, Chemist to the State Board of Health. (Resolves of 1898, chapter 4, January, 1899.)

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The Extension of the North Metropolitan Sewerage System Outfall at Deer Island, Boston Harbor, by Clarence A. Moore, Assistant Engineer, Metropolitan Sewerage Works. Journal of the Boston Society of Civil Engineers, Vol. IV, No. 3, March, 1917.

Annual Reports of the Metropolitan District Commission for 1920 and 1921.

Personnel

Metropolitan Sewerage Commissioners

From 1889 to 1892. — Hosea Kingman.
Tilly Haynes.
Robert T. Davis.
From 1892 to 1895. — Hosea Kingman.
Tilly Haynes.
Harvey N. Collison.
From 1895 to 1896. — Hosea Kingman.
Tilly Haynes.
Albert F. Noyes.

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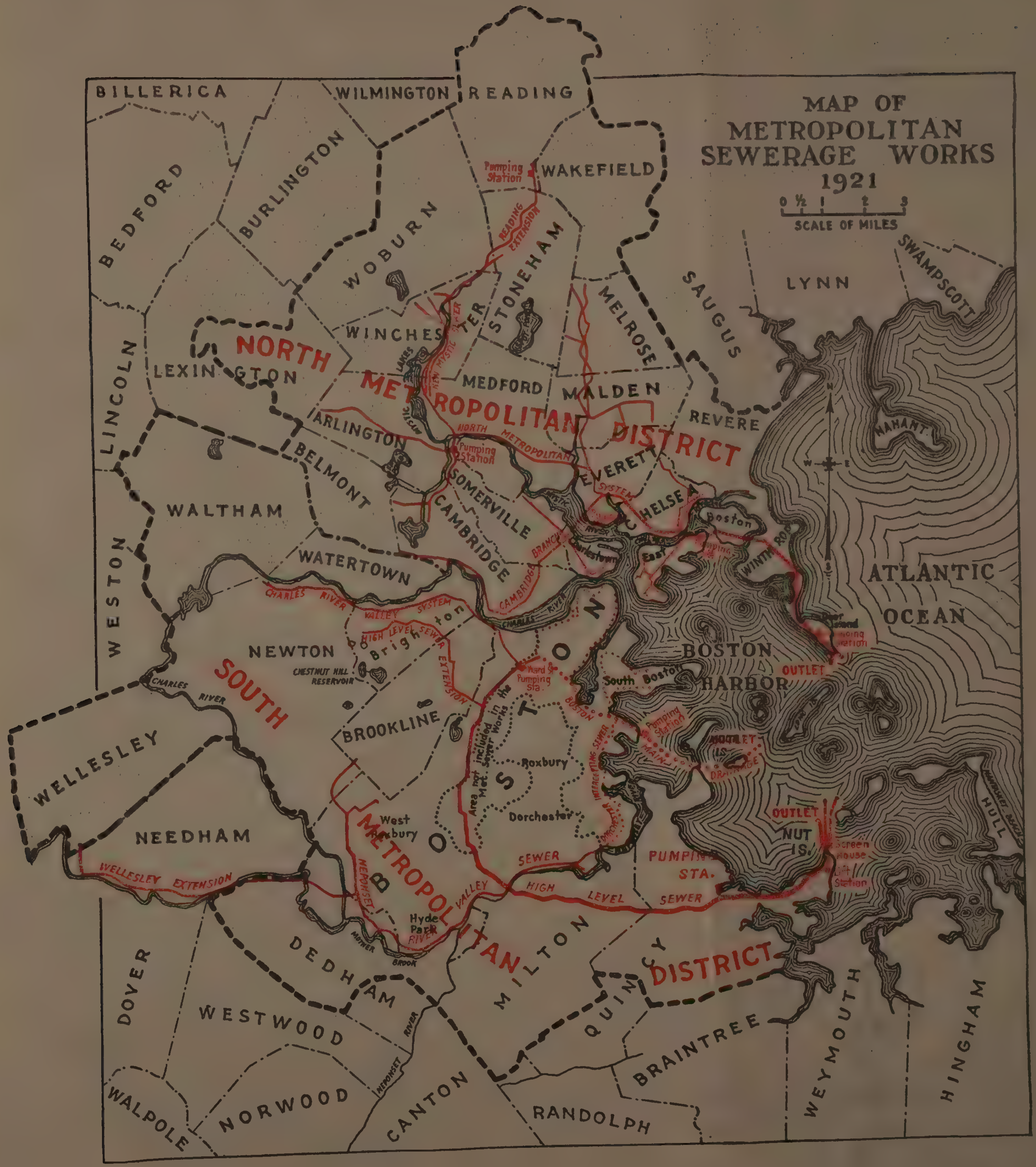
THE METROPOLITAN
SEWERAGE WORKS.



From 1896 to 1900. — Hosea Kingman.
Tilly Haynes.
George A. Kimball.
From 1900 to 1901. — James A. Bailey, Jr.
Tilly Haynes.
George A. Kimball.

Metropolitan Water and Sewerage Board

From 1901 to 1913. — Henry H. Sprague.
Henry P. Walcott, M.D.
James A. Bailey, Jr.
From 1913 to 1914. — Henry H. Sprague.
Henry P. Walcott, M.D.
Charles S. Hamlin.*
Edward A. McLaughlin.†
From 1914 to 1918. — Henry P. Walcott, M.D.
Edward A. McLaughlin.
Thomas E. Dwyer.
From 1918 to 1919. — Henry P. Walcott, M.D.
Edward A. McLaughlin.
James A. Bailey.

Metropolitan District Commission

From Dec. 1, 1919, to 1920. — James A. Bailey, *Commissioner.*
Ellerton P. Whitney,
Frank A. Bayrd,
Frank G. Hall,
William H. Squire,
} *Associate Commissioners.*
From 1920 to 1921. — James A. Bailey, *Commissioner.*
Frank G. Hall,
William H. Squire,
Frank A. Bayrd,
George B. Wason,
} *Associate Commissioners.*

Clerks of Metropolitan Sewerage Commissions

From 1889 to 1898. — Edward P. Fisk.
From 1898 to 1901. — Herbert E. Brayton.

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* Resigned Aug. 1, 1913.

† Appointed September, 1913.

Secretary of Metropolitan Water and Sewerage Board

From 1901 to 1919. — William N. Davenport.

Secretary of Metropolitan District Commission

From 1919 to date. — George Lyman Rogers.

Chief Engineers of Sewerage Works

From 1889 to 1895. — Howard A. Carson.
From 1895 to 1912. — William M. Brown.
From 1912 to date. — Frederick D. Smith.

ACTIVITIES OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES

Reforestation in New England

The source of New England's principal home-produced raw product has long been her forests. Naturally she was the pioneer in the paper and pulp industry. The time has now come, however, when there are more mills than can be supported on the home grown product and New England is importing much of its wood. The embargo on wood from the crown lands of Canada is already having its effect upon New England's supply and further Canada threatens to place an embargo on all of her wood.

When the Federated American Engineering Societies organized its Committee on Reforestation it was realized that this problem was of great and growing importance to many branches of the engineering profession. The conditions in New England are but an example of the many problems that are confronting other parts of the country. The F. A. E. S. Committee on Reforestation, working in close coöperation with the Bureau of Forestry of the Federal Government, is endeavoring to enlist the coöperation of other organizations to assist in the efforts for reforestation and the prevention of wastes in industries. The elimination of these wastes is in effect conserving the forests. A review of some of the existing conditions is most convincing evidence that the engineers in coöperating in this work can do a great public service.

The Federal Bureau of Forestry needs larger appropriations under the Weeks Act of 1911 to permit it to hasten the work of purchasing lands for national forest reservations. Last year the Budget Committee cut the 1923 appropriation to $50,000, but this was later raised to $450,000 in Congress. In order to carry on the work properly the Forest Service needs $2,000,000 annually, principally to permit the work of purchase to continue efficiently. For example, the purchase of lands in the White Mountains National Forest Reserve is only 45 per cent completed. That is, of the one million acres authorized for purchase in the White Mountain region by the National Forest Reserve Commission there have been only 450,000 acres actually purchased.

Originally there were nearly 10 acres of virgin forests per person for a population of 100,000,000. Today there are only 5 acres of virgin and second and third growths per capita, a reduction of 50 per cent in the acreage of all grades of timber growth. The present day acreage consists of approximately 30 per cent of first growth, 25 per cent second growth in a fair reproduction condition, 30 per cent second growth of inferior or questionable value; 15 per cent or 80,000,000 acres of waste land without suitable seed trees and hence unable to reproduce timber through the working of nature. This acreage has been burned over many times and therefore represents a difficult problem of reforestation.

In considering the total forest area of the United States and its depletion, it is well to note the relation between the forest area of North America and other sections of the globe.

The entire forest area of the continents is distributed as follows, according to the Bureau of Forestry:

	Per Cent.
North America	15.7
South America	36.3
Asia	25.9
Europe	12.4
Africa	8.0
Oceania	1.7

The second growth over the entire forest area of the world is some 62 billion cubic feet. In some countries the annual growth equals the annual consumption; in others it is less. In still others, which include Canada and United States, the production far exceeds the consumption. It would appear, therefore, that there was an ample supply of timber production for the world's consumption.

However, this is somewhat misleading, as the timber upon which the present civilization depends is the timber from common trees of the temperate zones, such as pine, spruce, larch, fir, oak, birch, hickory, and a few others. The rate of decrease of such woods is rapid. Therefore, the world is facing a shortage of soft woods, and these soft woods are likely to play a very important part in the economic and in the social shifts in the world's affairs before many years.

The foregoing has indicated that the virgin forests of the United States have been reduced to approximately 40 per cent of the original; that the world's supply of soft woods is being rapidly depleted; that dependence upon importations of soft woods is hazardous; that the day is rapidly approaching when the supply of merchantable timber will play an important roll in the economic and social aspects of the nation, especially throughout New England.

It would be possible to enumerate a number of important industries dependent upon soft woods in order to show that in any effort to conserve our present timber supply and to project plans for the growth of a supply for the future, concerted action is essential. No one agency can accomplish much. There must be the fullest coöperation and exchange of information, such cooperation and exchange of information as has characterized the paper and pulp industry.

Representatives of the Federated American Engineering Societies have urged the industry to study the report of Waste in Industry and direct its attention to what might be done in a broad and a comprehensive way to eliminate the waste of basic material and to perpetuate an ample supply of timber.

There are many evidences that a profligate waste of timber is occurring within the United States. Dr. Compton, Secretary and Manager of the National Lumber Manufacturers Association, recently stated before a Congressional Committee:

> It is asserted on competent authority that the present movement within the lumber industry alone for prevention of waste in lumber utilization involves a possible saving to producers and consumers of not less than $250,000,000 annually; and that in the field of logging, manufacture, distribution and final utilization of all forest products, the possi-

> bilities of total savings to the public and to industries, are in excess of $500,000,000 annually. This saving is largely a problem of increasing industrial and commercial efficiency. It is an industrial and not a governmental problem.

The waste in the woods in the form of tops, limbs, fairly large logs and stumps aggregates about 16.6 per cent of the total volume of the standing tree; and that in manufacturing the log into lumber, lath, shingles and the like, 44.3 per cent of the volume of the tree. Only 33.5 per cent of the tree leaves the sawmill as undressed lumber; between the undressed lumber at the sawmill and final form in which it is used there is a large percentage of avoidable waste and eventually only 17 to 20 per cent of the standing tree is used in the finished commodity, — a loss of approximately 80 per cent between the standing tree and the finished commodity. Much good work has been done by the Forests Products Laboratory and other agencies in reducing this waste, yet the work should be speeded up and more active support given.

Another very large source of waste of the present supply and of that of the future is due to forest fires. These have been brought under control perhaps more successfully in Vermont and New Hampshire than any where else in the United States. Other New England states are making special efforts for fire protection and while Massachusetts has perhaps a more important and better organized system of fire protection than the foregoing states, it registers more loss from fire, which fact officials of the Forest Service attribute to the earlier spring. In the general work of fire fighting and reforestation the U. S Forest Service is permitted to match with equal funds appropriations made by states. Unfortunately, however, this provision of the Weeks Act is practically void because of the fact that Congress does not make sufficient appropriations to match all of the state appropriations. For a six-year period, the average annual loss of property in the United States from forest fires was $16,424,000. This great loss resulted from 33,500 fires per year. The acreage burnt over was 7,088,000 annually. What this means to future generations no one can predict. But it is of sufficient moment not only for the future, but for the present, to challenge the earnest attention of engineers as well as that of every other group interested in safe-guarding the economic and social status of the nation.

There appears to be a marked lack of standardization throughout the field of timber production and consumption. This fact contributes in no small way to the wasteful use of the timber supply. For instance, there are about 6,000 brands of paper, 50 per cent of which are more or less active. There is an enormous wastage of paper in conversion processes. The measurement of 927 catalogs showed that there were 147 different sizes. Oftentimes a purchaser will specify a dimension, which is really immaterial to him, which will require either the cutting of a fractional amount from a standard sheet or the manufacture of special size sheet, either of which is a wasteful practice. A wastage of only one-fourth inch on a 6 by 9 page is equal to 7 per cent of the total cost of the paper.

Although many other avenues of waste could be pointed out, our attention must also be devoted to the topic of producing a future supply of soft woods, — reforestation. It is not sufficient merely to conserve what we now have, although much can be done in that direction. We have been so wasteful that the growing of a future supply is imperative.

The Middle Atlantic States contain 31 million acres of heavily culled or logged lands. The Lake States have 35 million acres of such lands. The Bureau of Forestry estimates that we are likely to have some 470 million acres of land that will be largely non-productive unless timber culture gives it employment. Much of New England's supply is exhausted and the drift is now toward the Western Coast, and particularly to Alaska. However, such supply is far removed, and in securing it increased costs and delays are encountered and transportation mediums and charges become very serious factors.

Reforestation is an economic factor of first importance in relation to a future supply of forest products. This is true of course in other parts of the United States as well as New England. It is specially pleasing to note results of the action of the State of Massachusetts in floating a bond issue sponsored by the State which permits of the purchase of one hundred thousand acres of state reserves. This purchase is being put on a sound business basis so that returns from lands so purchased will not only pay for the interest, but will be amortized so that the entire bond issue will be cared for by returns from the forest lands themselves. Other New England states have bought some lands for reforestation purposes in a somewhat similar manner.

It is also a factor of economic and social importance for still another reason, and that is for the preservation of water power and supply.

It is an encouraging fact that many individuals and agencies are awake to the conditions and are endeavoring to apply suitable check mates. This is an effort that requires support and encouragement.

The problem of the elimination of waste as it concerns the paper and pulp industry crystallizes as follows:

> *First.* The elimination of waste within the industry itself through the action of the management in general. This is necessary because many causes for waste do not inherently abide in any given plant and, secondly, many wastes within a given industry can be successfully dealt with only through the processes of research, standardization and free interchange of information. These require the expenditure of much time and money, the expenses of which and the results of which should be shared by and participated in by the industry as such.
>
> *Second.* Endeavor to secure a material reduction in the appalling waste of the basic material in the forests, at the saw-mills and in the processes of fabrication of commodities. This offers a rich field for accomplishment, which accomplishment will be realized only to the degree that all interested industries and professions should assist in securing a national long time constructive plan. The Bureau of Forestry cannot do all the work. It is a problem of such magnitude and importance as to challenge the earnest coöperative and continued support of all concerned.
>
> *Third.* The future supply of timber, the preservation of the lands, the conserving of the water power of the land demand that a practicable, comprehensive and all inclusive reforestation plan and schedule be devised and put into execution.

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BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PROCEEDINGS

MINUTES OF MEETINGS

BOSTON SOCIETY OF CIVIL ENGINEERS

BOSTON, September 19, 1923. — A regular meeting of the Boston Society of Civil Engineers, was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.45 P.M. by the President, Frank M. Gunby. There were about 90 members and guests present.

The minutes of the previous meeting were approved as printed in the June JOURNAL.

The President announced the names of those elected to membership by the Board of Government June 29, 1923, and September 19, 1923.

June 29, 1923. *Grade of Member:* Edward P. Hamilton, Francis H. Mitchell, Truman H. Safford, Albert C. Titcomb.

Grade of Junior: Edward S. Averell, Percival S. Rice, James M. Robbins.

Sept. 19, 1923. *Grade of Member:* Kimball R. Garland, William R. McCann, George T. Rooney.

Grade of Junior: Olcott L. Hooper.

Grade of Associate: Vincenzo J. Grande.

The Secretary announced the death of Rudolph Hering, a member of the Society, who died on May 30, 1923. The President announced that he would appoint a committee to prepare a memoir.

The President announced that the subject of the meeting was "Apprenticeship in the Boston Building Trades," and introduced Mr. Wm. Stanley Parker, President of the Boston Building Congress and President of the Commission on Apprenticeship for the Boston Building Trades, who spoke on the general situation up to the present time.

The next speaker was Mr. George T. Thornton, Second Vice-President of the Bricklayers, Masons and Plasterers International Union of America, who told of the unprofitable results of former systems of apprenticeship in the bricklayers and masons crafts, stating that the new system promulgated by the Commission on Apprenticeship would receive the hearty co-operation of the crafts whom he represented.

Major Heywood S. French told of the endorsement of the new plans for apprenticeship by the Building Trades Employers Association, whom he represented on the Apprenticeship Commission.

The final speaker was James M. Gauld, Agent for the Carpenters' Union of Boston and Secretary of the Massachusetts State Council, United Brotherhood of Carpenters and Joiners of America; also a member of the Apprenticeship Commission. Mr. Gauld outlined conditions in the carpentry trade both in the past and present and prophesied great improvement in the future under the new system of apprenticeship, which has already been accepted by the members of that trade.

Following these speakers, a general discussion took place which shed additional light on the subject, both from the viewpoint of the employer and of the craftsman. At the close of the discussion a rising vote of thanks was accorded to those not members of the Society who had presented this subject in such an interesting manner.

The meeting adjourned at 9.45 P.M.

J. B. BABCOCK, *Secretary.*

APPLICATIONS FOR MEMBERSHIP

[October 15, 1923]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

For Admission

Anthony, Sidney S., Manchester, N. H. (Age 24, b. Providence, R. I.) Graduate of Manchester High School, one year at New Hampshire College, one year at Worcester Polytechnic and at present at Northeastern University. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls and W. E. Nightingale.

Barton, Kenneth Lawrence, Boston, Mass. (Age 19, b. Grantham, N. H.) Graduate of Kimball Union Academy and at present in Northeastern University. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls and W. E. Nightingale.

Bray, Wesley Richard, Boston, Mass. (Age 21, b. Torrington, Conn.) Entered Northeastern University in September, 1921. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

Buck, Harold Albert, Boston, Mass. (Age 24, b. Springfield, Mass.) Graduated from High School and now a student at Northeastern University. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

Carchia, Michael Arnold, West Roxbury, Mass. (Age 22, b. Newark, N. J.) He was a student at Tufts College from September, 1919, to January, 1923, and is now at Northeastern University. Refers to R. Abbott, H. B. Alvord, J. H. Bartlett, C. S. Ell, J. W. Ingalls and W. E. Nightingale.

Cohen, Morris, Dorchester, Mass. (Age 25, b. Russia.) Now a student at Northeastern University. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls and W. E. Nightingale.

Connor, Wilbert Hamilton, Orient Heights, Mass. (Age 20, b. East Boston, Mass.) He has been a student at Northeastern University for the past two years. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

Houser, George Crouse, Marblehead, Mass. (Age 25, b. Akron, O.) A graduate of Harvard College in 1920. then entered Harvard Engineering School and in 1922 received degree of B. S. in sanitary and municipal engineering. In October of 1922 became assistant investigator on the City Planning Board of Boston and remained there until August, 1923, when he became sanitary assistant in the engineering division of Massachusetts Department of Public Health, where he is at present employed. Refers to W. C. Eberhard, H. J. Hughes, W. A. Liddell, G. F. Swain, G. C. Whipple and E. Wright.

King, Arthur Maurice, West Medway, Mass. (Age 21, b. Franklin, Mass.) Graduate of Medway High School and is now in Northeastern University, third year. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

Langtry, Chester F., Framingham, Mass. (Age 21, b. Dorchester, Mass.) Has been a student at Northeastern University three years. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

Oakes, Edward Joshua, Roxbury, Mass. (Age 25, b. Boston, Mass.) Graduate of Mechanic Arts High School in 1916, special course at Northeastern University in 1921 and 1923. Was in the bridge department of Boston & Maine Railroad, 1918–1920; nine months with Chas. T. Main, February, 1920, to November same year detailing and designing; taught mechanical drawing from September, 1921, to June, 1922; drafting on Boston Police Building that summer; in charge of tank installation September, 1922, to November and from November to September, 1923, detailing and designing on Edison job. Now teaching mechanical drawing and manual training. Refers to B. S. Brown, P. Jones, A. W. Knowlton, E. P. Lane, E. D. Mortenson and T. W. Proctor.

Parker, Burton Cranston, Boston, Mass. (Age 19, b. Holden, Mass.) Is a civil engineering student at Northeastern University. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

Richards, Charles N. A., Milton, Mass. (Age 21, b. Milton, Mass.) Is a student at Northeastern University, third year. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

Stearns, Elton Otis, Waltham, Mass. (Age 22, b. Waltham, Mass.) Has been a student at Northeastern University from September, 1920, to date. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls and W. E. Nightingale.

Stephenson, William Gerard, Needham, Mass. (Age 19, b. Dorchester, Mass.) A student at Northeastern University. Refers to H. B. Alvord, C. S. Ell, C. J. Ginder and J. W. Ingalls.

LIST OF MEMBERS

Additions

Averell, Edward S.	Lynnfield, Mass.
Garland, Kimball R.	75 Winchester St., Brookline, Mass.
Grande, Vincenzo J.	22 Hull St., Boston, Mass.
Jones, Frederick E.	80 Elm St., West Somerville, Mass.
McCann, William R.	147 Milk St., Boston, Mass.
Mitchell, Francis H.	Essex Company, Lawrence, Mass.

Changes of Address

Alcott, William J., Jr.	13 Benham St., Medford Hillside, Mass.
Armstrong, Wallace E.	Box V, Capitol Station, Austin, Tex.
Brask, Henry	88 Gainsborough St., Suite 1, Boston, Mass.
Burrage, Henry T.	636 West Sedgwick St., Philadelphia, Pa.
Durham, Henry W.	Sandwich, Mass.
Foyer, Charles P.	17 Sydney St., Dorchester, Mass.
Fuller, William B.	General Delivery, El Paso, Tex.
Jackson, Ralph T.	R. F. D. No. 91, Attleboro, Mass.
Junior, Francis E.	2 Butler Road, Stoneham, Mass.
Longfellow, George P.	112 Chandler St., Boston, Mass.
MacWilliams, Harold F.	28 Riverside Pl., Walpole, Mass.
Milne, David C.	62 Horne St., Readville, Mass.
Nichols, Hall	6 Summit Rd., Watertown, Mass.
Rivkin, Bernard M.	60 West St., Hyde Park, Mass.
Toole, Cameron S.	Box 11, Otis, Mass.
Wells, Edward P.	Lisbon, N. H.
Wentworth, John P.	14 Beacon St., Boston, Mass.
Willey, Lawrence V.	Turner Cons. Co., 208 Main St., Sanford, Me.

Deaths

Bullock, William Dexter	April 30, 1923.
Parker, Theodore	June 14, 1923.

LIBRARY NOTES

Recent Additions to the Library

U. S. Government Reports

Birth Statistics of United States. 1921.
Fourteenth Census of United States. Vols. 5, 8 and 10.
Water Supply Papers. Nos. 506 and 515.

Municipal Reports

Bangor, Me. Annual Report Water Board. 1922.

Marlborough, Mass. Annual Report of Water Commissioners. 1922.

Milwaukee, Wis. Activated Sludge Sewage Disposal Project.

Newton, Mass. Annual Report of City Engineer. 1922.

Woonsocket, R. I. Annual Report of Water Commissioners. 1922.

Worcester, Mass. Annual Report of Superintendent of Sewers. 1922.

Miscellaneous

American Society of Heating & Ventilating Engrs. Guide. 1923.

American Society of Mechanical Engineers. Transactions. Vol. 44.

American Society of Municipal Improvements. Convention of 1922.

History of Electric Light. By Henry Schroeder. Gift of H. S. Knowlton.

Proceedings of Institution of Civil Engineers, London. Vol. 215.

Library Committee.

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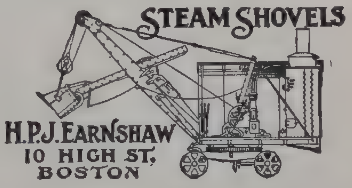

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